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TABLE OF LEADING ARTICLES.

Professional Fees 171
Revision of the New York Building Code.......... 171
The Electrification of the New York, New Haven & Hartford R. R.............................. 172
Gas Power in the Operation of High-Speed Interurban Railways. (Illustrated.) 174
Suggestions on Specifications for an Engineer's Transit and Level. (Illustrated.) 178
High-Pressure Gas Distribution.................. 181
Waterproofing at the Subway Power House, New York. (Illustrated.) 182
Early German Steam Engines..................... 182
The Heating and Lighting Plant at Bryn Mawr College 183
The Water Power Development of the Chicago Drainage Canal. (Illustrated)......................... 187
Plate Girder Spans on the Chicago, Burlington & Quincy R. R. (Illustrated.).................... 191
Removal of Iron from Water...................... 191
Overdriven Piles. (Illustrated.)................. 192
The Detroit River Tunnel of the New York Central Lines. (Illustrated.)......................... 193
The "Indiana" Claim in the Court of Claims....... 194
The Storage and Handling of Members for the Island Span of the Blackwell's Island Bridge. (Illustrated.) 195
The Gas Engine Pumping Station at Posen........ 196
Book Notes 197
Heavily Loaded Reinforced Concrete. (Illustrated.). 198
Damp-Proofing 198

Professional Fees.

The subject of fees for services rendered by engineers is by no means a new topic for consideration in the profession. It has been much discussed both by itself and in connection with the ethics of the profession many times, and it must be admitted that while the results of those discussions have not always been such as to meet all requirements of the case, much real progress has been made toward reaching the desired ends of uniformity and amount. The fees of architects and engineers are founded practically on the same general considerations when they relate to the same class of subjects, viz., the design and building of structures. When, however, professional service is rendered in a more general or less tangible way, so as to serve business or professional ends of magnitude though not subject to quantitative treatment, the amount of the professional fee cannot be fixed by the usual five per cent. commission or on any other percentage basis. In such cases obviously the fee must be the subject of agreement between the engineer and his client. If the interests subserved are extended and the service demands grave professional responsibility from the engineer such fees are properly large. Great financial interests are frequently involved and the service rendered may and does affect in many cases the safe or successful investment of capital, either for public or private parties, and the fee should be commensurate with the importance or gravity of all the elements of the project or enterprise. That rule holds in the legal profession and it holds with the engineering profession in Great Britain, where the services of the engineer are probably more adequately recognized than anywhere else in the world, and it is a matter of simple business fairness and justice that they should be similarly recognized in this country or anywhere else.

The observation made above touching the recognition of the value of engineering service in Great Britain involves considerations which may well be taken most seriously by American engineers. There is probably no other country where there have been more marked instances of engineering energy and courage in the design and construction of work than in the United States. The conditions under which American engineers have undertaken great projects of many kinds have been such as to demand the greatest possible professional capacity, and yet in many respects engineers themselves have failed to give the requisite dignity or adequate weight to their own service. It was but a few years ago that there was a most active and extended discussion in the American Society of Civil Engineers regarding professional ethics in engineering. Certain conventional procedures or regulations were proposed by some to insure adequate recognition of the profession by the public, or at any rate by those portions of the public requiring the services of engineers, as if by some formal professional legislation such ends could be accomplished. As a matter of fact, no formal or informal professional legislation, so to speak, can insure adequate recognition of the profession any more than morals or any degree of virtue can be legislated into a community. Whenever the members of the engineering profession as a whole give to their services the value and the dignity which attach to or are commensurate with a truly earned large fee, such fees become reasonable and they are reasonable only under such circumstances. As long as engineers confine themselves to narrow technical service, as distinguished from the broader exercise of professional powers affecting correspondingly large interests, small fees commensurate with a narrow and more or less crude view of professional service will be received, for none other can be reasonably exacted.

Unquestionably the general conditions of engineering services in connection with large business or commercial interests in Great Britain have much to do with reputed large fees for engineering services there, but on the other hand those members of the profession who receive such fees are broadly qualified, highly trained professional men whose qualifications are, as a rule, of the highest order. They are men who not only appreciate the purely technical side of things which they have to deal with but they are also capable of dealing with larger and broader interests, and are thus enabled to control far greater forces than those dealt with even in engineering science. What the engineering profession needs is not so much a higher degree of technical training or more legislation, either formal or informal, but a broadening and expanding of the professional view of things. Many engineers, though there are probably not as many as there were, still take the view that members of the profession should be restricted to purely technical service and should not occupy executive positions, either in municipal service or in the service of public or semi-public corporations. No greater mistake from a purely professional point of view could be made. It is obvious that no man without executive capacity should undertake to fill an executive position, but there are many engineers of unusual executive capacity, as the actual experience of many corporations has demostrated beyond any possible question. Such engineers make most efficient executives. Their educational training and the habit of an accurate recognition of things as they are, qualify them to deal in the most successful manner with the greatest interests found in any field of administrative work. In other words, those engineers will receive the greatest fees who take the broadest and highest views of their professional work because they are entitled to them. They demonstrate title to adequate reward, consequently they obtain it.

It is not to be supposed that a uniform schedule of fees will hold throughout the whole field of professional work. In great communities where interests affected are correspondingly large and far-reaching and where the responsibilities attached to professional services are exacting in the highest degree, fees will be larger than in a different environment, where less responsibility is attached to professional action and where the environment is of a simpler and less exacting character. At any rate that observation will hold with the broader discharge of an engineer's functions. In the design and building of structures both the engineer and the architect in the smaller community may properly expect the five per cent. commission for the standard service which is usually covered by it, provided that service is of the same quality and equally effective with that of his professional brother in the large city. To sum up the whole situation, then, it may be stated that the professional fee in any case will be largely, if not entirely, that which the professional man himself makes it by the efficiency, the character and the dignity of the service which he renders. Any professional man who, with a sense of the full responsibility resting upon him, gives his service expression and force under those broad general principles will seldom or never fail to find the response which he desires from his clientage.

The Revision of the New York Building Code.

It will probably be recalled by a good many engineers and architects that early in the year, when the Board of Aldermen of the City of New York passed an amendment to the Building Code modifying the regulation concerning so-called fireproof wood in high office buildings, the mayor of the city vetoed the amendment on the ground that the regulation was inserted in the Code by the Commission which prepared it, presumably only after careful consideration, and their decision should only be changed after equally careful consideration by an equally competent body. About the same time the mayor requested power to appoint a committee to draft a new building code, but this right, granted to the Board of Aldermen by the city charter, the Board decidedly objected to delegating to anybody. It is well known that experience with the Code has shown the necessity of modifying some of its requirements and of incorporating new provisions which will bring it up to date; the necessity of this is shown by the fact, among others, that reinforced concrete construction has received its marked impetus since the regulations now in force were drafted, while some of the older methods of detailing building work have been changed in important respects, which make the present requirements needlessly onerous.

All classes interested in building in the city have been impressed by the desirability of revising the Code and accordingly the Board of Aldermen was recently persuaded to pass the following resolutions: "Resolved, That in pursuance of Sec. 407 of the Greater New York Charter, the Building Committee of this Board be, and it hereby is, directed to prepare and report to this Board a Building Code, in amended and revised form, providing therein for all matters concerning, affecting or relating to the construction, alteration and removal of buildings or structures erected, or to be erected, in the City of New York; and it is further Resolved, that for the purposes of properly preparing said Building Code the said committee be, and it hereby is, authorized to engage the services of the following experts, each of whom shall be a resident of the City of New York, and shall have been engaged not less than five years in his respective calling, to wit: a builder, an ironworker, a mason, a carpenter, a plumber, an architect, a civil engineer, a sanitary engineer, a physician, and a lawyer, which said experts shall be paid a reasonable compensation for the services rendered by them, the compensation to be fixed by this Board after the service has been rendered."

The text of this resolution shows that the Board of Aldermen appreciates the wide effect that a good Building Code has on the trades and business of the city adopting it. The Board has endeavored to secure a representation on the expert commission of all those callings or professions which are most directly affected. The object is praiseworthy, for only those who have once learned how many are the interests affected strongly by such regulations can appreciate the task of preparing a satisfactory and at the same time useful Code. Nevertheless it is a question whether the Board of Aldermen cannot accomplish its object most quickly by authorizing a change in the personnel of the proposed expert commission. The commission must act in a judicial capacity as well as initiate its own plans, and a very important part of its proceedings will be the consideration of the claims put forward by the dealers of different building materials. The members should, therefore, be selected mainly with a view to their accurate technical konwledge of building design, materials and construction, as otherwise it is probable that undue importance may be attached to those people who are represented before the commission by the best talkers.

It is probable that, under the conditions that exist in New York, the architect is better acquainted than anybody else with what should be required in the way of design and materials in order to ensure the construction of safe buildings. Accordingly the commission ought to include at least two architects. The next class in interest is unquestionably the builders. Most of the leading building contractors in the city are men who began as journeymen and are thoroughly acquainted with their trades, so that they not only represent the contracting element but also the workmen in so far as the workmen's interests need representation. It might be stated in this connection that the chief interest to the workmen in the revision of the building laws lies in securing good construction, so that their lives are not hazarded while they are working, and for this reason rules which improve the character of the design will also work for the protection of the artisans. It is difficult to see just what good will come from having masons, carpenters or ironworkers on the commission. So far as the structural design of large buildings is concerned it goes without saying that the professional man who is best fitted by education and experience to act both as judge and designer is the civil engineer, and for this reason it will be well to have on the commission at least two members of this profession who have been identified with the best work in the city. Fortunately there are a number of such engineers who enjoy a high reputation for professional knowledge and common sense in building affairs, so that a selection of representatives from this class is not difficult.

This leaves four members to be selected from among those interests which are vitally interested in building affairs, but not so directly in their structural aspect as the architects, builders or engineers. Probably nobody will question that the fire insurance companies should be consulted in any revision of the Code, and for this reason a member of the National Fire Protection Association should be included in the commission. In order that no legal pitfalls may remain undiscovered a lawyer with experience in real estate and building law will prove a useful member of the commission. The Code will have to be interpreted by the officers of the Bureau of Buildings, who are probably better acquainted with the deficiencies of the present Code than any other class of people, and for this reason a representative of that Bureau should surely be a member of the commission. Finally there is no class which is so well posted concerning the commercial value of buildings and the character of buildings useful in different parts of the city as the real estate agents, and it is manifest that, in spite of their tendency to find fault with any laws which retard the sale of property, one representative of this class should be included on the commission.

This leaves an organization of ten men representing every feature of building operations and interests which are assumed to be covered by a building code. It is organized to initiate of its own knowledge any changes that may be desirable, and is fully competent to pass on any questions that may be submitted to it. It may safely be claimed that a commission so made up will not only formulate a better code than an organization like that suggested by the aldermanic resolution, but will do so more promptly and inexpensively to the city. It is accordingly to be hoped that the Board of Aldermen will see fit to allow its committee to adopt a different composition of the expert commission than that at present proposed by the Board.

The Electrification of the New York, New Haven and Hartford R. R.

It is hardly necessary to say that no feature of railway operation is of more interest at the present time than the electrification of the New York, New Haven & Hartford R. R. from Stamford to Woodlawn, a distance of 21.45 miles. At Woodlawn the road connects with the New York Central tracks running into the Grand Central Station, a distance of 11.13 miles. The New Haven system will be single-phase, the New York Central system direct-current, and consequently the equipment of the New Haven company must be capable of running on either system. There is a feeling on the part of some electrical engineers of high standing that the difficulties of commutation of powerful single-phase motors have been underrated, but there is no way to prejudge the matter theoretically and only experience will show whether single-phase locomotives are a possibility. The fact that Mr. Westinghouse stakes his professional reputation on his ability to turn out a good single-phase locomotive is at present the best non-technical argument for the type. The difficulties of commutation with small motors have been successfully overcome, but only experience will show whether the far greater difficulties with motors of large capacity can be successfully met. It is for this reason that the New Haven experiment is so important, and fortunately we shall soon know about the matter, for experiments with the first of the New Haven locomotives will probably begin at Pittsburg in less than a month.

The alternating current system of operation derives its great advantage from its simplicity of distribution of current from the power house. With the direct current the necessary apparatus includes the generators in the power house, the high-voltage feeders to the sub-stations, transformers at each sub-station to reduce the voltage and rotary converters to change it to direct current, the trolley wires and the car motors. With the alternating current system the equipment consists of the generating appaartus in the power station, a high voltage line which is also the trolley line, a small transformer on the car and the car motors. By the second system the amount of wire is reduced and the use of the rotary converters is rendered unnecessary, two very important advantages.

The power station of the New Haven installation will be at Cos Cob, where plenty of condensing water can be obtained and there is an opportunity for securing coal by barges. The engineers of the station, Messrs. Westinghouse, Church, Kerr & Co., will install 9,000 h.-p. of water-tube boilers and four 3,000-h.-p. Parsons turbines. Single-phase current at 11,000 volts and 25 cycles wil be supplied to the main line and three-phase current for running air compressors for the signal system and for a small amount of power for other purposes along the line. The location of the station is such that it will be suited for furnishing current to the New Haven line as far east as New Haven, and it is not improbable that on the completion of the electrification of the work now in hand this extension eastward will be made. The overhead wires will be carried by bridges spanning all of the tracks every 300 ft., each wire being central over the track it feeds. The trolley wires will be No. 0000 and as there will be from four to six of them no auxiliary feeders will be required. They will be suspended by ⅝-in. steel cables, each wire by two cables, to which it will be connected every 10 ft. It will be hung in this way at a uniform height of 22 ft. above the rail, which leaves a clearance of 3½ ft. above the head of a 6-ft. brakeman on top of a standard freight car. This height will also be ample, it is believed, to prevent the corrosion of the wires by the gases from the freight locomotives passing below. This system does away with all the objections raised by railway operating officials to electric traction.

The road will be divided into blocks about 2 miles long, considerably shorter than the present blocks, and there will be a tower with a signal man at the end of each block. The tower man will have under his control oil circuit breakers in each trolley wire, which will enable him to stop the operation of the trains on any track in the two blocks between which his tower stands. A relay feeder on each side of the bridge at the tower will provide against interruption to the service on more than one block at a time. This is a manifest advance in security over the present conditions.

The company proposes for the present to haul all of its trains by electric locomotives, although multiple-unit trains may be used later. It has not been considered desirable to complicate the present situation by using the multiple-unit train now for several reasons, among which may be mentioned the use of both alternating current and direct current between Stamford and New York, the necessity of simplifying operations at the outset, the absence of any stops between Mt.

Vernon and New York, and the desirabiliy of using the present rolling stock so far as possible. Each locomotive unit weighs about 72 tons and consists of a steel frame mounted on two four-wheel trucks, each axle being driven by a 250-h.-p. motor. The motors have an ingenious form of suspension by which not only the weight of the field, but also of the armature is supported on springs. When the locomotives are in service on the New York Central tracks each pair of motors will be connected in series and operated as a unit. The electro-pneumatic system of control is used. Each locomotive is expected to be capable of handling a 250-ton train between New Haven and New York under the most severe local schedule conditions. For heavier trains two or more units will be coupled together and operated as a single locomotive by means of the multiple unit system of control. It will be noticed that this division of the locomotives into comparatively small units not only reduces their first cost, but also keeps down the maintenance of the locomotives and of the track, while affording unusual flexibility for the handling of heavy trains. It is expected that under the normal 11,000 volt line tension and with the average train weight of the New Haven system the locomotives will be able to maintain a maximum speed of 80 miles per hour on a level tangent.

It will be of interest to a good many railway officers to know that this test of the single-phase system will not be an expensive matter, as such things go. The power house will cost about $1,130,000, the overhead line construction $570,000, and the thirty-five locomotives, $1,050,000, or a total of $2,750,000. As already stated, nobody knows whether it is possible to design a single-phase motor of this size until the experiment is tried. The New Haven officers will doubtless have an opportunity of testing the first locomotives before others are built and if the tests prove unsuccessful, which Mr. Westinghouse's positive assurances render extremely unlikely, the power house will still be available for direct current operation and the expenditure for locomotives, making up nearly a half of the total, will be saved for the purchase of other equipment. The risks of the installation are manifestly largely borne by the Westinghouse companies, but the railroad company deserves all the credit for willingness to try a promising but novel experiment of great magnitude.

Notes and Comments.

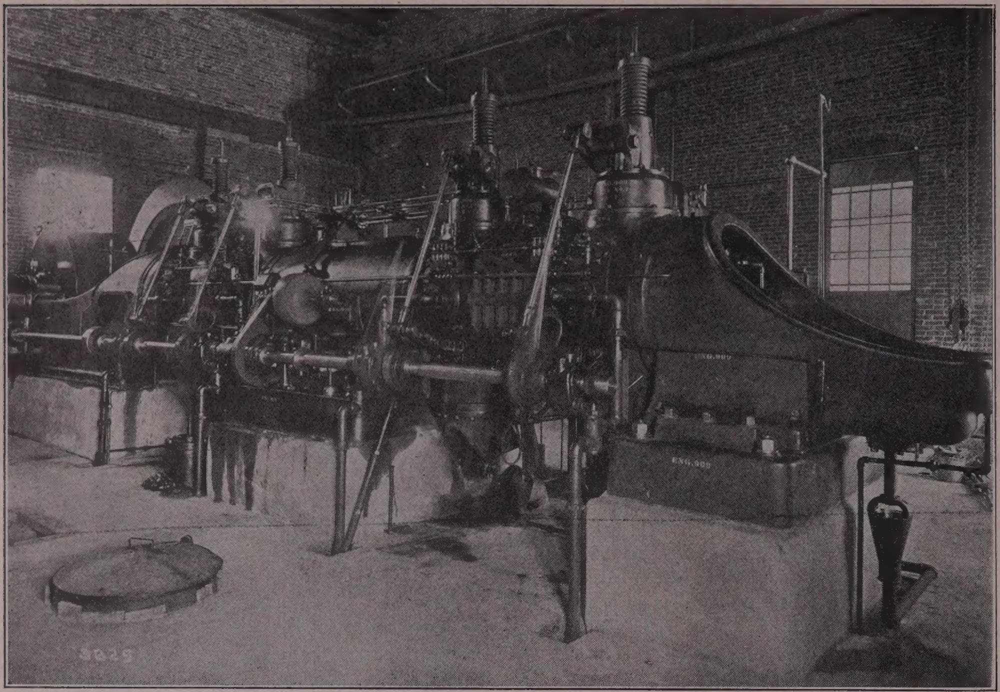
Economy of Fuel at coal mines has only lately been considered desirable, yet in the few years it has received attention some very interesting results have been obtained. For example, at the Eureka mines of the Berwind-White Mining Co., where about 3,000,000 tons of soft coal are produced annually entirely by mechanical means, the fuel consumption with substantially the same outputs was decreased from about 8,400 tons to about 7,300 tons annually, by replacing five 1,500-ft. straight-line compressors by three compound steam Corliss compressors of 3,000-ft. capacity each, and by discharging 2,000 gal. of water per minute from the mines by a duplex compound condensing steam pump instead of by compressed air. Mr. C. E. Watts stated at a recent meeting of the Engineers' Society of Western Pennsylvania that still further economies would result from the substitution of other equipment more economical than that now in use, particularly in the electric generating line. During the development of these collieries machinery was installed which was known to be reliable, but the idea of economy of energy production was on the obscure horizon. In 1903-4, after the desired coal production had been obtained, it was found that the amount of generated energy would soon be insufficient to maintain the production as the mine workings drew further away from the power stations, and for this reason more economical power equipment became desirable.

The Comptroller of the City of New York deserves a round of applause from every man or woman who has been thrifty enough to save and invest a little money. At a recent meeting of the city authorities, called to pass on the proposed tax on the Pennsylvania R. R. projects in Brooklyn and Queens, he vigorously opposed any holding up of public corporations for all they would pay for permission to carry on their business. As was stated in this journal recently, a tendency has grown up to fix prices for permission to do business on private property that is wholly wrong and opposed to the public interest. A company which proposes to occupy a street with a line or two of railway should pay a good price for the right. This right is a franchise and a valuable one in many cases. On the other hand the privilege of crossing a street above or below its surface, which is the desire of the Pennsylvania R. R., is not a franchise but an easement. Many property owners grant such easements to their neighbors, to allow them to run drains or other conduits across their property to street mains. They have a small value, but nothing like the value which attaches to the right to use the surface of land. The Pennsylvania R. R. asked for easements of this nature and expected to pay for them, but it was held up for excessive payments on the theory that valuable franchises were being granted. Fortunately the new comptroller is an experienced business man, and he very promptly and emphatically opposed any such unjust action.

The English Channel Tunnel Project has been revived as a result of the closer relations between Great Britain and France, and it is said that the prospects of the enterprise were never so bright as they are now. It was about thirty years ago that the Societe Francaise du Tunnel Sous-Marin was incorporated with a capital of about $400,000 for the purpose of carrying out this undertaking. The French terminus was fixed about 6 miles from Calais and the English terminus near Dover. A shaft was sunk on the French side and considerable tunneling done. Finally, after the company had spent its original capital and $100,000 more, the British government refused to allow any work to be done at the English end, lest the completed tunnel should afford an easy means for the invasion of the country by a hostile army. At least, this is the reason put forth for the British veto, although it is not unlikely that some more real objection to the project was the true cause of the action taken. Last summer engineers of the Northern Ry. of France made an investigation of the abandoned works and of the conditions of the problem as a whole and the next session of Parliament will see the introduction of a bill for permitting the work to go on. So far as is now known the only serious difficulty in driving such a tunnel, which will be approximately 23½ miles long, is in connection with its ventilation. The material to be penetrated is chalk and the actual tunneling operations will probably not be troublesome. The project deserves careful attention in these days of great railway enterprises, because its successful prosecution will afford a means of crossing the English channel without any of the discomforts that attend the present passage by boat. The channel is a most unpleasant place to those who are not good sailors, and it is safe to say that a tunnel railway between the two countries would have a very large traffic.

Workmen's Insurance and Relief Funds are being investigated by the Bureau of Labor of the Department of Commerce and Labor. This is more important than may at first appear, for the United States is far behind the leading European countries in its provisions of this nature. In Germany in particular, the government has made it obligatory to contribute to such funds, and many establishments have found it to their advantage to carry their insurance and pension funds even farther than the government requirements. The systems in force at Essen have long been noted for their effect in building up among the workmen a strong feeling of reliance on the owner of the great Krupp works and this is all the more interesting because the Krupp establishment is a remarkable example of an autocratic industry, practically controlled by one person. In London a different method of accomplishing the same end has been followed by the powerful gas companies, and there are some establishments in France that are practically co-operative, owing to the extent to which their operatives are given assistance in sickness and old age and a share in the profits. The investigation of the Bureau of Labor wil cover particularly insurance against sickness, accident, disability, old age, death and lack of employment. It will also look into the existence of what are known as establishment funds, restricted to the employes of a single company and supported by the men, the companies or both. Information on this subject is requested by the Board and The Engineering Record trusts that its readers having data concerning it will send them to the Commissioner of Labor. It is impossible for the investigation to be thorough unless such information is volunteered, for the existence of many such funds is known only to the small circle of employes and officers of each company.

The Commission of Gas and Electricity of the State of New York has submitted its first annual report, which shows that it has accomplished a good deal in the six months of its existence. One of its works has been the compilation of a table showing the maximum and minimum prices charged for gas in the cities of the State. When the commission has been in office somewhat longer it will know that such tables are as dangerous as gunpowder in a cooking stove. They really do not mean very much, because the cost of the product depends on the expense of every item making up the total fixed and operating charges of the manufacturing establishment. In the case of gas there are to be considered the difference in cost of coal, the difference in the cost of mains per hundred consumers, the difference in the average consumption of gas per street tap, and many other factors. Accordingly a charge that is high for one locality may be low for another. None of these things are taken into account by the local demagogue, however, and if his sphere of influence happens to be a place where operating charges are necessarily high he will use these State-given figures to raise all sorts of trouble for the local company. The gas business is not so highly profitable in the Empire State just now that there is any need for worrying the gas managers. The commission reports that only a few of the companies are paying any dividends, and it is a well-known fact that until the gas heater and stove appeared as a relief to the situation, the competition of electric companies was very severe. If the gas companies are given an opportunity to charge a reasonable price for their product and their managers introduce stoves, heaters and incandescent mantles energetically there is an excellent field for small gas plants still, but if the figures which the commission supplies are to be used as weapons for a raid on prices, then the future is not so encouraging.



View of Valve Gear Side of Gas Engine While Running.

GAS POWER IN THE OPERATION OF HIGH SPEED INTERURBAN RAILWAYS.

Experience on the Warren & Jamestown Railway System.

By J. R. Bibbins.

The degree of engineering initiative required for the successful execution of an undertaking such as the Warren & Jamestown system, recently placed in operation, lends special significance to the results already achieved. Operating as it does the entire railway system in the vicinity, both urban and interurban, and thus assuming a high degree of responsibility in public service, the Warren & Jamestown system deserves special notice, not only in the adoption of the high-voltage single-phase railway system, but also in the exclusive use of gas power. The combination of these two elements establishes a precedent in the history of transporation.

The successful application of the large gas engine to railway work has been awaited with much concern, and the operation of the Warren plant has already contributed much valuable and encouraging experience. To obtain a clear idea of the conditions surrounding this particular service the railway system may first be briefly described.

Territory.—Operating between the two largest towns in the vicinity, traverses a territory well populated, and exceptionally well situated to develop an extensive freight business. The right of way, 22 miles in length between termini, passes through nine towns, totaling 50,000 population. Nine contiguous towns with a population of 11,500, bring the total tributary population up to 61,500, exclusive of summer residents. As the vicinity is a popular summer resort, the maximum tributary population is estimated close to 100,000 people. No direct competition exists, there being only a branch connection at Jamestown by trolley from the Dunkirk, Allegheny Valley & Pittsburg R. R.

Right of Way.—In general the line is of good construction (70 lb. rail, gravel ballast), direct and fairly level, but abounds in curves with a few heavy grades, one in particular being of special difficulty, owing to its length (¾ mile), steepness (7 per cent. maximum), and a necessary stop at the foot. These conditions unfortunately conspire to impose upon the power equipment a fluctuating load unusually severe at times.

Rolling Stock.—Elegant in general appointments, the rolling stock presents one of the most interesting features of the road, particularly in the facility with which the cars are handled, and the easy and uniform acceleration obtainable. All controller points being running points, there is none of the disagreeable jerking in series and parallel running conditions often encountered in direct-current service. Five cars are at present in use, including a baggage or light freight car. Later two more passenger coaches will be placed in service. The cars are 52 ft. in length over all, having a seating capacity of 59 persons, and weigh about 35 tons total. They are equipped with four 50-h.-p. Westinghouse single-phase series motors connected in multiple with duplicate drum controllers. A multi-voltage transformer receives normal line pressure at 3,300 volts, delivering 550 volts to the motors, various lower voltages being used for different running speeds. These cars make a daily schedule speed of 19½ miles per hour, with stops averaging every 2½ miles. On through runs without stops an average speed of 30 miles per hour has been maintained. Maximum speed range as high as 50 miles per hour.

Electrical System.—All power for the a.-c. line is transmitted at 22,000 volts pressure to two 300-kw. transformer stations located about 1½ miles from the respective termini. Here the voltage is reduced to 3,300 and delivered to the overhead trolley, which is entirely of Westinghouse catenary construction. Current is collected from this overhead by bow trolleys held in contact position by compressed air.

Within the city limits of Warren and Jamestown, where this high voltage is not permissible, an ordinary 550-volt span wire trolley construction is employed, paralleling the direct-current trolley. The current is here collected by ordinary trolley wheels which, however, are insulated for 3,300 volts for use on the high-voltage trolley in case of accident to the bows.

Half way between termini the overhead is sectioned, the Warren end being supplied from one transformer station, the Jamestown end from the other, two separate transmission lines being run from the power house bus to the respective stations. It thus occurs that the loads on each end of the system are mutually independent, except in their effect on the generating plant.

Warren Street Railway System.—In addition to the foregoing interurban equipment, the company operates all the city lines in Warren, totaling 9 miles of single track, with seven cars in normal service. These are single truck, two motor equipments, weighing about 10 tons total. Formerly operated as a separate system, the Warren Street Railway now receives power from the main power house, operating in conjunction with the alternating-current equipment.

The Power Station.—Although greatly enlarged for the reception of the new machinery, the old power-house site at Stoneham, a few miles south of Warren, is still used. Owing to the abundant supply of cheap fuel gas in the neighborhood, the Warren company at the time of its organization, several years ago, decided to experiment with gas power for running their system. The results have been so much better than would be possible with gas-fired boilers and steam machinery as to practically dictate the selection of gas engines for this more recent and more important service.

Furthermore, the Warren & Jamestown Co. was not unmindful of the increased responsibility which would necessarily follow from the establishment of an interurban system in the matter of delay and inconvenience to passengers from interruptions to power supply, and it was apparent to them that the more reliable type of prime mover was an absolute necessity. To meet these conditions the Westinghouse Machine Co. was commissioned to provide the gas-engine equipment of a type best known as the "heavy duty type," familiar to steam engine practice.

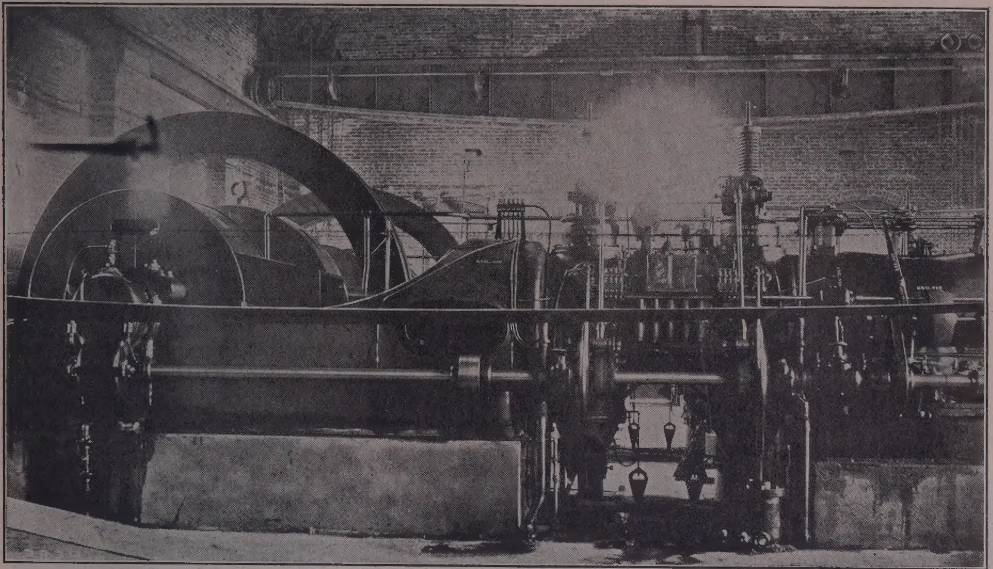
Up to the present writing the results obtained have more than fulfilled the expectations of all concerned. For operating the entire system, both city and interurban, the cost of fuel gas averages less than 7½ cts. per car-hour.

The plant was started on Oct. 19, and has been in continuous service since, averaging 17½ to 18 hours, without developing, in the least, troubles of a serious nature. After a two months' run, the first unit started was shut down for the purpose of examining its condition. Every part was found to be in perfect working order without the least evidence of deterioration or excessive strains, and even the original toolmarks were apparent in the cylinders.

The new equipment is located in a rectanguar brick structure, directly adjoining the old gas-engine plant, which is still maintained as a reserve in the case of emergency. A few months prior to the opening of the interurban system a 300-h.-p. vertical type Westinghouse gas engine was installed to drive a rotary converter, the machine first serving the d.-c. city road, and later the a.-c. interurban road, until the main power units could be placed into service. This "rotary" is now employed to good advantage for supplying the city system from the main alternating-current plant, operating as a simple rotary. In case either side of the a.-c. or d.-c. plant requires assistance this rotary will be belted to the reserve engine, operating either as an a.-c. or d.-c. generator. A 150-ampere (hour rating) storage battery assists in absorbing the fluctuations of the city load. It floats on the system without a booster and was first installed for purposes of regulation to assist the old gas-engine plant.

There are two main gas generating units at present installed, with space for a third of equal size (260 kw., 500 b.h.p. nominal). Single-tandem units were employed in place of twin tandem in order to give greater flexibility of operation. The units are without spring couplings between engine and generator and operate in parallel on the station load precisely in the same manner as an ordinary steam-driven unit.

Load Peculiarities.—A most noteworthy feature of the plant is its ability to cope with the violent fluctuations in load due to the demand for current on heavy grades and simultaneous starting of cars. Owing to the small number of cars in service at any one time the individual power demands are most keenly felt at the station and rarely overlap in such a manner as to smooth out the station load curve. As a result, the load imposed upon the generator units is incessantly fluctuating, frequently from zero to maximum, which would tend to extreme difficulty in accomplishing good regulation, not only in potential, but particularly in speed. For the former a voltage regulator has proven of assistance; for the latter a sensitive relay system of governing, which holds the speed of the engine so close that variations can scarcely be detected by the ear, which, as is well, known, is extremly sensitive in this regard.



Side View Looking through Opening between Piers.

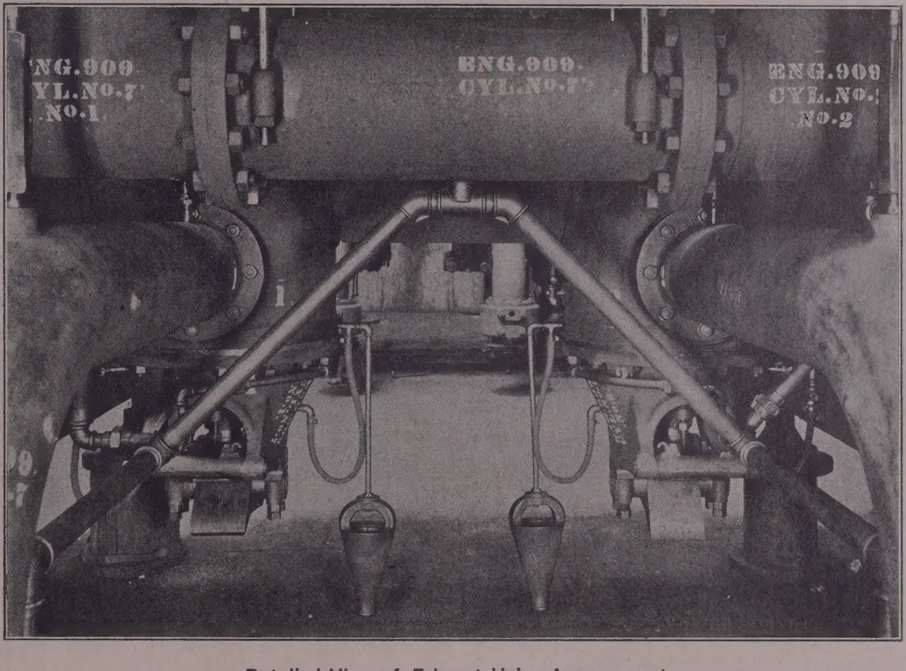
In observing the operation of this system it is immediately apparent that the load conditions could not possibly be more unfavorable to the generating plant. This fact emphasizes the success which has already been obtained.

General Design of Gas Engine.—If any one feature characterizes the general design of this engine it is the strong adherence to approved steam engine practice; in fact, the frame and cylinder structure parallels that of the horizontal tandem Corliss engine, and the experience of builders in large Corliss work has been directly embodied in the new gas engine design, many of the structural features having been found equally applicable to the latter. The engine, therefore, stands not as an example of radical change in structure, but as an adaptation of steam experience to gas work.

The engine operates upon the familiar Beau de Rochas, or four-stroke cycle, with practically constant quality of mixture. With the tandem cylinder arrangement one power impulse is obtained on each forward and backward stroke, the resulting crank effort being equivalent to that of a single-cylinder double-acting steam engine.

Cylinders are 21 in. in diameter by 30-in. stroke, the unit running at a normal speed of 150 r.p.m. The engine as actually rated at 470 h.-p., with a guaranteed maximum of 520 h.-p. This conservative rating corresponds to a maximum overload capacity of 35 per cent. on the generator. For more uniform loads, in which violent fluctuations do not ordinarily occur, a higher electrical rating is possible.

Early in their experience with horizontal gas engines the builders became convinced of the absolute necessity of accessible parts. Later experience has proved this point. In comparison with the benefits to be derived from having all parts of the engine above the floor level, the increased cost in foundations is immaterial. Unfortunately this makes the engine look much larger in comparison to the generator it drives than it really is, due somewhat also to the high generator speed.



Detailed View of Exhaust Valve Arrangement.

Auxiliaries capable of automatic working have proved to be extremely desirable. The continuance of cooling water supply or lubrication should not be dependent upon the caprice of an indolent attendant, as the possibilities of danger are too great. The modern prime mover to be a success must be as near "fool-proof" as possible, and the designer is forced to contend with the possibilities of cheap labor.

In order to suit the present American market and the labor conditions existing here, it has been a special endeavor of the builders to simplify the construction and operation of gas engines to the greatest possible degree compatible with the economy desired. It would obviously be poor engineering to retain complicated and expensive construction where the last degree of economy was not desired. The first and most important problem is to build an engine that runs well, refinements calculated to secure fine-haired economies can then be applied when desired.

Finally, the modern gas engine has, definitely outlined before it, the highest standards of steam-engine practice in regard to the operation of a.-c. generating machinery. It is gratifying that this standard has been met without equivocation in any respect, as proven by the operation of the Warren & Jamestown system.

Frame and Cylinder Arrangement.—Accompanying photographs of the interior of the power station show clearly the general cylinder arrangement. It will be observed that the cylinders are supported clear from the foundation by main, center, and rear frames respectively. Only the main frame is anchored; others rest upon sliding ways to accommodate expansion and contraction of engine body. To insure permanence of alignment, the cylinder ends are recessed into their respective frames. The foundation body terminates at the floor level, separate piers rising 30 in. above the floor. This construction carries the exhaust valves and every working part of engine above floor line; the accompanying illustration looking through the two engine foundations at the exhaust valve illustrating this point. All upper works are readily accessible from a cast-iron platform running along the front side of the engine at about the center line.

In this particular engine, the main frame is of center-crank construction with heavy box-girder bed and long sweep crank pit. It is held down by eight 2½-in. through bolts. All guides are bored, and the crosshead is accessible from above. The middle housing is cylindrical, with the upper front quadrant cut away for access to center crosshead; it is closed by heavy tie rod. The rear housing is cored out beneath for the waste-water chamber.

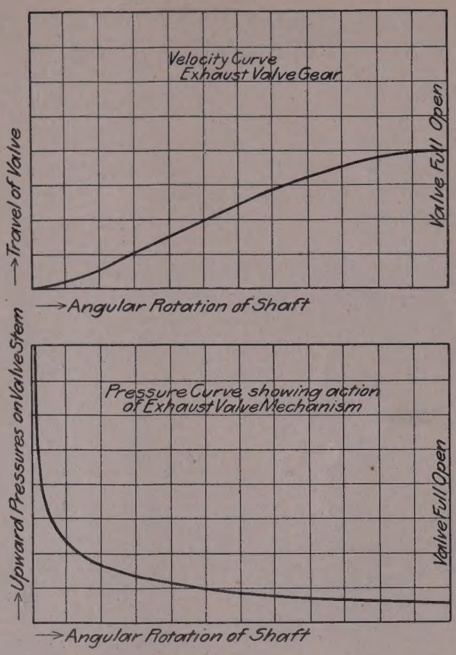
Crankshaft and Bearings.—The crankshaft is of solid forged steel 16½ in. in diameter at the main bearing. Oil grooves and bored ducts convey the lubricant by positive pressure to pin.

The bearings are of segmental construction, with the bearing cover locking over upright guides to secure greater strength. The main bearing is in three parts, the lower shell resting in a bored seat. The shell may be readily removed from above by jacking up the shaft. The shells are cored for water cooling if found necessary, and are faced with hammered babbitt. Large handholes through the bearing cover are convenient for inspection.

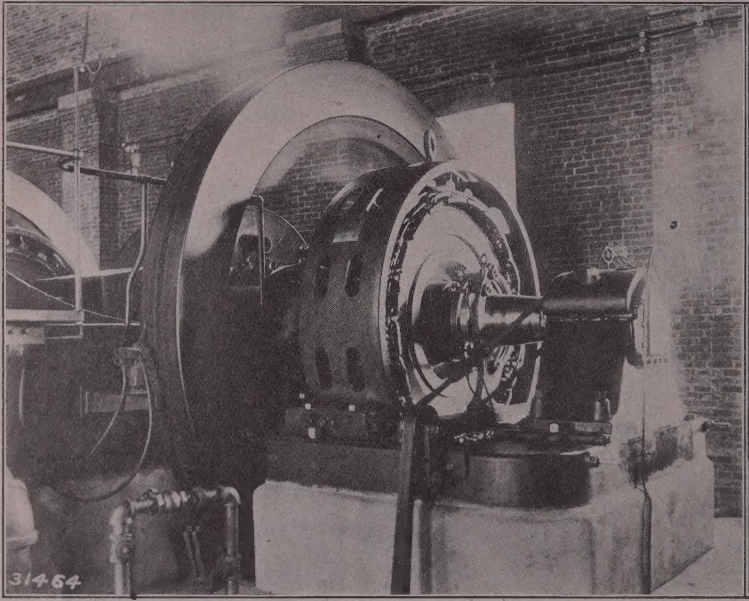
Connecting Rod and Crosshead.—The connecting rod is also of forged steel, with a solid end at the crosshead and an open end at the crank, a locking piece at this point retaining the two-part bronze box. No straps or bolts in shear are used. A wedge adjustment is used at both ends.

The crosshead is of cast steel, with a single slipper locking over the ends of the crosshead, so that wedge adjustments may be used without reversible stresses or shear in the bolts. The slipper is turned cylindrical inside and out to permit ready removal sidewise after easing off the weight. The crosshead pin is of forged steel with continuous taper, removable through an opening in the housing with the aid of special starting clamp.

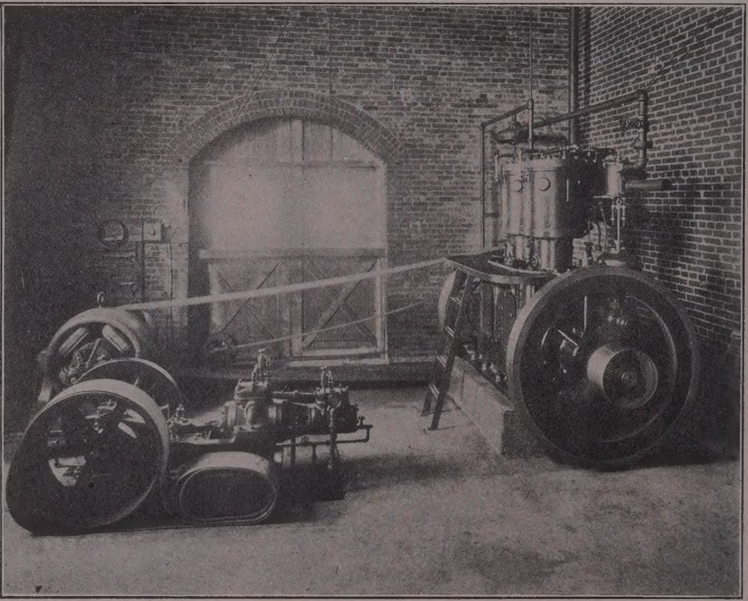
Cylinders.—The cylinder body is of perfectly symmetrical construction, partly enclosed by jacket walls, a split jacket band being used to close the opening. This construction permits ready adjustment of strains due to shrinkage and unequal temperatures between cylinder and jacket walls, and also gives ready access for cleaning jackets.



Velocity and Pressure Curves, Exhaust Valve.



Generator End, with Stop Device on Flywheel Rim.



Exciter, Igniter, Air Compressor and Gas Engine.

A distinctive feature of the cylinder design is the location of valve chambers for vertical access at each end of the cylinder structure. The advantages of this arrangement, especially for dirty gas, are obvious, and by properly timing the several events of the working cycle approximately perfect scavenging may be obtained without danger of premature ignition or dilution of incoming mixture. But most important, by removing a valve at each end of cylinder, the interior is readily accessible for cleaning through spacious openings. With any other construction it would be necessary to remove the cylinder head entirely to accomplish this result satisfactorily.

The heads are in one piece and cored with suitable water passages independent of the glands. Their removal is easily accomplished by a special clamp bolted to the outer face, so shaped that the center of gravity of the head falls directly under the eye bolt of the clamp, thus avoiding any binding on the shaft as the head is removed.

Pistons, Rods and Glands.—Several important features have been embodied in the design of these parts; first, a symmetrical piston structure without internal ribs; and second, a two-piece piston rod. In the case of the pistons it has been found advisable to depart from steam engine practice in using a ribbed box piston and to employ a structure which shall be free to expand unrestrained by ribs or webs of any description. This result has been accomplished by a peculiar arrangement of internal parts performing the functions of both closing piece and water duct. The pistons are cast in one piece, and when the internal parts are assembled they are forced on the rods with hydraulic pressure. In addition they are secured by a recessed nut, which is afterwards turned off in a lathe flush with the piston surface. This construction is by intention permanent, and, in assembling or dismantling the engine the piston and rod are handled in one piece.

The rods are of forged nickel steel, with a water duct drilled through the center. They are screwed into the main, center, and rear crossheads and secured by keys. The center crosshead is constructed in the form of a split screw coupling resting upon and dowelled into the crosshead support, which is cast as a separate piece and removable sidewise. This coupling thus acts as a closing piece to the piston structure, and enables repairs to be made upon one section of the engine without disturbing the other, during which time the remaining cylinder could be kept in service if necessary. The water duct of each rod section is closed at the ends by plugs, and a deflecting plug is inserted in the center line of each piston for the purpose of diverting incoming water into the piston channels.

Much importance is attached to "floating" the pistons absolutely clear of the cylinder walls through adjustment provided at the various crossheads. Rods have been so proportioned that requisite stiffness is provided to carry the weight of the piston without undue flexure, thus the piston rings alone are in contact with the cylinder, resulting in much less friction and wear, especially with dirty gas. Each piston has four segmental cast-iron rings set out with flat springs. An important advantage in regard to lubrication will be mentioned under that head.

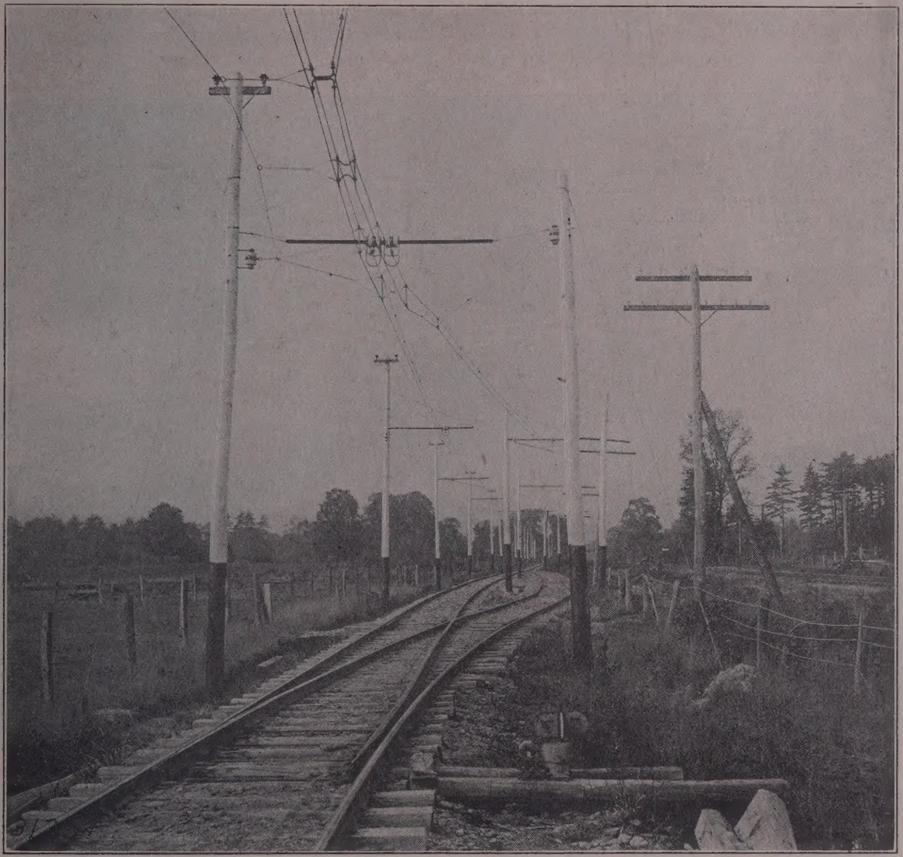
By the use of segmental metallic packing rings arranged in series along the rod the difficult problem of providing tight packing without undue friction has been solved. An important property of this packing is that it "floats," thus easily absorbing slight variations in alignment due to flexure of rod. The several packing rings are mounted in a separate ring cage, independent of the head, and removable in one piece.

Valves.—Poppet or mushroom type valves are used for both the exhaust and inlet valves. They are all steel, seating in the direction of pressure by suitable springs and mounted in bonnets removable vertically from the cylinder casting without dismantling any of the lay shaft gear.

The inlet valve performs functions of both admission and governor valve, but not until gas and air reach the interior of valve itself are they mixed in proper proportions. The possibility of premature firing is thus reduced to the minimum. There are two distinctive operations in the working of the valves; first, vertical motion, opening the gas and air ports to the cylinder; second, rotation, by which the quantity of the mixture admitted is proportioned to the load on the engine. The proper ratio of gas to air is maintained constant by butterfly dampers in the separate gas and air ducts leading from the mains to the individual valves. As each valve is directly under governor control it thus occurs that the engine can take only such volume of mixture as is needed at the instant to maintain speed; closer regulations is thus more readily obtained than in arrangements where distance intervenes between the governor valve and inlets. A valuable feature of this valve is that a somewhat richer mixture is obtained on very light loads to insure greater certainty in ignition. The valve is operated by cam motion, special attention having been given to the inertia of parts and velocity of fluids in the valve chambers.

Exhaust valves are driven by separate eccentrics. By means of a special form of multiplying motion there are obtained two extremly desirable features; first, concentration of lifting forces as the valve leaves its seat against the heavy pressure of exhaust; second, rapid opening as soon as the valve is in motion. These characteristics are well shown in the accompanying curves. With a comparatively light linkage great power is exerted at the start, followed by maximum velocity of opening when most desired. Valves are of solid cast steel resting in a cast-iron yoke with suitable ports for conducting the in-and-out cooling water. This water rises through the center of the valve and discharges downward through a concentric tube, so arranged as to always keep valve full of water.

Both inlet and exhaust valves are operated by one lay shaft paralleling the engine cylinders, and geared 2 to 1 direct to the main shaft. Air starting cams are also mounted on this shaft. A flange coupling near the driving end permits of small angular adjustment in either direction.



View of Track and Overhead Construction.

Governing.—A first principle in sensitive governing is that the regulator must not be required to actuate valves of large mass or dimensions, but rather that its sensitiveness should be reserved for regulating purposes only. Along this principle an oil relay system has been developed in which a reciprocating piston operating under 40 to 50 lb. pressure does the actual work of inlet valve movements. It is controlled by a small pilot valve which is alone actuated by the regulator. As the pilot is balanced, very little work is impressed upon the regulator. This relay system has proved most successful, as, indeed, in its application to other forms of massive power machinery. A centrifugal type regulator is employed of great power and sensitiveness, and geared direct to main lay shaft. To obtain small speed adjustment for synchronizing and for distributing loads on alternating current generators, a device is used shown beneath the regulator in the accompanying photographs. This consists of a spring pulling on the dash pot arm of the regulator. Its lever arm may be shifted by a handwheel. Through the corrective action of this spring and the damping action of the dash pot, the governing system may be controlled to a nicety and from one point.

Oil for the relay cylinder is supplied by a small pump connected to one eccentric. This pump also discharges into a steel storage tank along the building wall, which is kept half full of oil. When the plant is being started compressed air at proper pressure is let into the top of the tank, and the engine is thus enabled to start off under positive governor control.

Ignition.—In no part of the engine is absolute surety against accident required more than in igniters; for this reason the hammer-break system is used. Long experience has proved this type to be the most reliable under all possible conditions. All igniter plugs are removable in one piece and enter the cylinder at a point just beneath the ignition valve and at a maximum distance from the exhaust opening. Duplicate igniters are available in each combustion chamber. A separate lay shaft paralleling and geared to the main lay shaft carries igniter cams which are set at quadrant. A valuable detail of this gear is the provision for simultaneously advancing or retarding ignition in all cylinders while the engine is running. This adjustment is conveniently located on the gear case of the drive and a graduated scale and index give the exact point of ignition.

Two sources of current are always available; first, current at 125 volts from a small generator belted to the exciter engine; second, current at eight volts, with spark coil, from a set of storage batteries maintained at full voltage by daily charging from the exciter bus. These batteries are of a type specially devoloped by the Westinghouse Machine Co. for the work. For purposes of increased security four separate switch cabinets are used, two to an engine, and the igniter circuits are so wired that each cabinet controls one end of each cylinder, thus making possible four separate igniter combinations in each combustion chamber.

In case of accident to any part of plant it is desirable to shut down in the shortest possible time; this is accomplished by a small switch conveniently located at the rear housing, which opens both igniter circuits. Another switch, in series, is mounted near the flywheel rim in connection with a centrifugal speed-limit device, which likewise opens the igniter circuits when speed has reached a predetermined limit. This switch is opened by a weight released by a small plunger sunk into the face of the flywheel.

Much importance is attached to the provision for changing an igniter while the engine is running. This is a rare necessity, but it needs to be recognized. The object is readily accomplished by temporarily cutting off the gas supply and relieving the cylinder compression. This method permits the other end of the cylinder to be kept in service and requires but a moment to make the necessary adjustments.

Circulating System.—Fortunately a source of pure cold water is available from a passing stream, which has been dammed for the purpose. A large concrete storage reservoir receives this water, the surplus overflowing to waste. A triplex pump forces this water into an elevated tank, from which it flows by gravity, to the engines under a constant net head of about 20 ft. This pressure has been found sufficient for all purposes at engines, including pistons and rods.

The pumping outfit is automatic, and as soon as the water level in the tank reaches minimum level, an automatic motor starter places the pump in operation until the tank is again filled. The system is simple and easily cared for, and has given good satisfaction. The cistern and tank hold about 1,000 and 300 barrels respectively.

At the engine, separate discharge outlets are provided for each important cooling water circuit. Furthermore, open funnels are inserted in the waste pipes so that the attendant can readily ascertain the temperature of overflow at any time. The cylinder, head, gland, and piston may thus be independently inspected at frequent intervals and the circulating passages kept open.

Obviously a moving water connection is necessary to deliver water to the piston rods. A special system has been devised having a twofold object; first, equal water temperatures in pistons; second, subdividing the mass so as to lower the pressure necessary to overcome the inertia of water. At the center crosshead two water ducts connect with the front and rear sections of the piston rod. These are supplied by a double-ended reciprocating plunger pump bolted to the crosshead. Large air chambers at the end of each plunger serve to absorb variations in pressure and to deliver a more uniform flow to piston. Thus at each forward and backward stroke the plunger connection delivers water to the front and rear pison rod respectively. Judging from the appearance of the overflows, however, the air chambers are effective in smoothing out fluctuations in pressure due to the motion of the plungers. This apparatus is very compact and possesses a merit that no knuckle joints are necessary, simply straight-line movement only being used.

Starting System.—A special operating feature of the engine is the simple method of starting, an adaptation of vertical gas engine practice. Compressed air storage tanks in the basement furnish the motive power at 200 lb. pressure. On the engine lay shaft are arranged four cams, engaging the stems of an equal number of small poppet valves which automatically inject compressed air into each combustion chamber at a time necessary to give the forward impulse. No manual adjustment of the valve mechanism is necessary. In starting there are but two operations; viz, opening; first, compressed air throttle, which sets all starting valves; second, gas throttle. Each valve then comes into play in the required order. After the first impulse, gaseous mixture is drawn into the cylinders in proper proportion, and with the succeeding ignition the engine rapidly comes up to speed. At this point the compressed-air system is automatically shut off by the pressure of combustion operating against special check valves at the point of entry to the cylinders. With this arrangement the engines can be readily brought up to speed inside of one minute, requiring the attention of only one man. A 250-h.-p. engine has been started repeatedly in 30 seconds.

Oiling System.—Automatic oiling devices have been applied at every possible point. On each end of each cylinder is a small sight feed plunger pump, operated from the eccentric. These pumps are filled from reservoirs located on top of the cylinders and separate ducts convey the lubricant to several points around the cylinder wall and to the middle of the glands. An important point is that cylinder lubrication is accurately timed so that its effect will not be vitiated by combustion before the lubrication has been accomplished. This also results in a reduction of the oil necessary to run the engine.

Engine oil is handled by a circulating and filtering system. It is supplied from under static pressure from an elevated tank to sight-feed manifolds. On various parts of the engine a large excess of oil is used so as to flush all working parts thoroughly, which finally drains back through the same filtering system. After thorough filtering and sedimentation, it is again elevated to the tank by a small geared pump belted to the main shaft. This system gives most perfect lubrication at smallest expense for oil.

Piping.—All main piping for water, air, or gas is carried out on the main and branch system, except the exhaust lines, in which case each is piped independently to avoid loss of power through frequent turns. During cold weather exhaust heat is needed for warming the building and keeping the jackets from freezing, but during warm weather sprays will be used to cool exhaust pipes. For conveying gas and air to the cylinder ports special piping is used with two ducts, connecting with corresponding ports in admission valves. This appears under the platform in the accompanying illustration.

Gas Supply.—Gas for all purposes is drawn from a supply system covering this territory and is available from several different points, in case of interruption to some part of the Gas Company's system. It is very uniform in quality, entirely clean, and averages from 100 to 1000 B. t. u. total. Gas is obtained at a straight price of 15 cents per 1000 ft., which places the cost of power so far beneath the usual figure that any other source of motive power is out of the question.

Operation.—Comparative observations on the operation, first, of the new plant running the entire system, and, second, both new and old plant runnning interurban and city systems, respectively, indicate the excellent economy of gas power. (See accompanying table.) During the week ending Jan. 12, the average amount of gas used per 17½-hour day was 89,285 cu. ft., running 10 cars, three interurban and seven city. In the month of December, 1905, the new plant operating the interurban system above consumed 1,701,000 cu. ft., the old plant operating the city system during the same period consumed 1,746,000 cu. ft., totaling 3,447,000. Upon the basis of the average week's run above noted, the new plant is able to carry the entire system at a saving approximately 20 per cent. in cost over the independent operation. During December the cost of gas necessary to run the interurban system averaged 47 cents per hour, or 15.7 cents average per car-hour for the 35-ton interurban cars.

The new gas power equipment is operated by two men to a shift with a third man during the day as general helper. Engineer Paulson is in charge. In general its operation to date has been most encouraging to the builders and has resulted in the undisguised satisfaction of the operators.

Cost of Operation 1,000-H.P. Gas Engine Plant, Warren & Jamestown Railway.

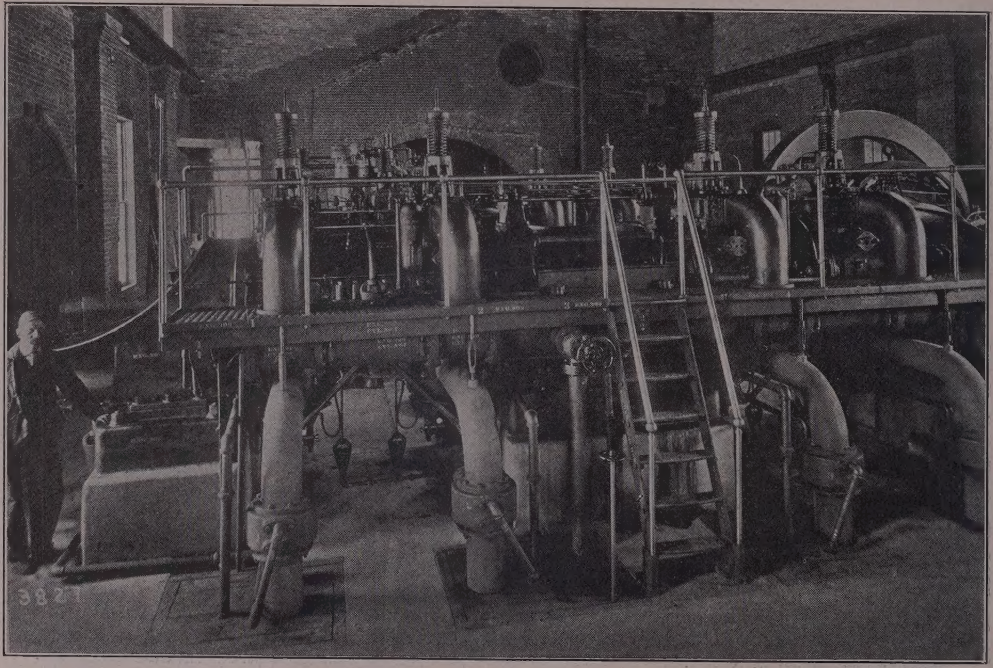
Interurban System Only, December, 1905.

Number of cars (35 ton)	3
Gas Consumed	1,701,000 cu. ft.
Gas per day averaged	54,900
Hours operated per day	17.5—18
Gas per hour (operation)	3,090
Cost of fuel per day	$8.24
Cost of fuel per hour run	0.464
Cost of fuel per car run	0.155

Interurban and City Systems, Jan. 5-12, 1906.

Number of cars—city (10 ton)	7
Numberof cars—interurban (35 ton)	3
Gas consumed	625,000 cu. ft.
Gas per day	89,285
Hours operated per day	18
Gas per hour (operating)	4,960
Cost of fuel per day	$13.40
Cost per hour run	.744
Cost per car hour	.0744

The success of the Warren & Jamestown undertaking is certainly well merited, and to Mr. D. H. Siggins, president of both companies, is due great credit for his exceptional far-sightedness and courageous initiative. With the assistance of his son, Mr. Hugh Siggins, he has organized and brought to full state of development a noteworthy public service system which many larger cities cannot parallel. The officers of the Warren & Jamestown Railway Co. are: Mr. D. H. Siggins, president; Mr. H. M. Preston, vice-president; Mr. S. Q. Smith, secretary; Mr. H. A. Siggins, is a director of the company and general manager of the Warren Street Railway.



Platform Side of Engines, Showing Exhaust Arrangements and Double-Duct Piping.

Reinforced Concrete is being employed on a most extensive scale at the Southampton docks of the London & South Western Ry. One of the most prominent examples is a cold storage warehouse 46 ft. high and covering a 400x120-ft. plot; it is supported on reinforced concrete piers. Another structure is a coaling wharf 350 ft. long and 20 ft. wide, which is carrying coal bucket cranes weighing 65 tons and mounted on a four-wheel truck having a 12-ft. wheel-base. Another work is a platform for about 1,500 ft. of quay, which is now in course of construction to carry two standard railway tracks and also traveling hydraulic cranes weighing 65 tons apiece.

Suggestions on Specifications for an Engineer's Transit and Level.

A paper read before the Illinois Society of Engineers and Surveyors by Leonard S. Smith, Associate Professor of Topographic and Geodetic Engineering, University of Wisconsin.

The more general use of the transit and stadia method for taking topography has made increased demands on the instrument maker for a better transit, especially along optical lines. Now, while it is true that for simple land surveying, less rigid specifications are sufficient, there can be no doubt that even this class of work would be rendered easier and more accurate by the use of a superior instrument. It was for similar reasons that the transit long ago supplanted the surveyor's compass.

This paper will attempt to point out in detail what improvements seem desirable. It may be marked, that the custom of purchasing instruments by competitive bids and of allowing each bidder to write his own specifications is obviously unfair to all concerned. Besides making all bids comparable, carefully drawn specifications should insure the purchaser receiving exactly what he proposed to buy. Surely the specifications of so important a part of the field engineer's outfit as is his transit and level, should receive at least as much thought and care as he gives to the purchase of his thirty-five-dollar bicycle. That this care and caution should be often entirely lacking is alike discreditable to his professional knowledge and business skill.

Fig. 1 gives a view of the first American transit, made by Young & Sons in 1825. Its close resemblance to the plain transit in use to-day emphasizes the fact that the constructive changes of the past 80 years, though in the aggregate considerable, have not been radical.

A knowledge of what constitutes an excellent transit for stadia topography and the methods of testing to discover the actual facts in a particular case, have seemed so important to the speaker that for several years he has made the study of the sources of error in instrumental design and the necessary laboratory work for their detection, an integral part of the required work of his surveying classes. In fact, part of the data, upon which his criticisms are based (including tests of sixty field instruments belonging to the University of Wisconsin), was secured by his students in their regular work above referred to.

Let us now inquire what features of the complete engineer's transit tachymeter are the most open to criticism, and what are the proper remedies. It is the writer's observation that the performances of the vertical circle and telescope level fall far short of what reasonably should be expected. The causes of this deficiency may be stated as follows:

First, too small a vertical circle.

Second, non-sensitive plate bubbles.

Third, the omission of a sensitive level from the vertical circle for the control of its zero.

Fourth, the use of irregularly ground and non-sensitive telescope level vials.

It is a well known fact that an error of several feet in the horizontal location of a topographic point would scarcely be discernible on a contour map of ordinary scale, while an equally large error in its vertical location might entirely vitiate the map for its designed purpose. In view of this fact, the time-honored custom of using transits with large horizontal circles, frequently reading to fractions of a minute, results in simply strengthening the work at a point already the strongest, while the custom which sanctions the use of small vertical circles weakens the work at a point where the greatest accuracy is needed. With a transit provided with horizontal and vertical circles of equal size, the elevations will still constitute the weakest part of the work.

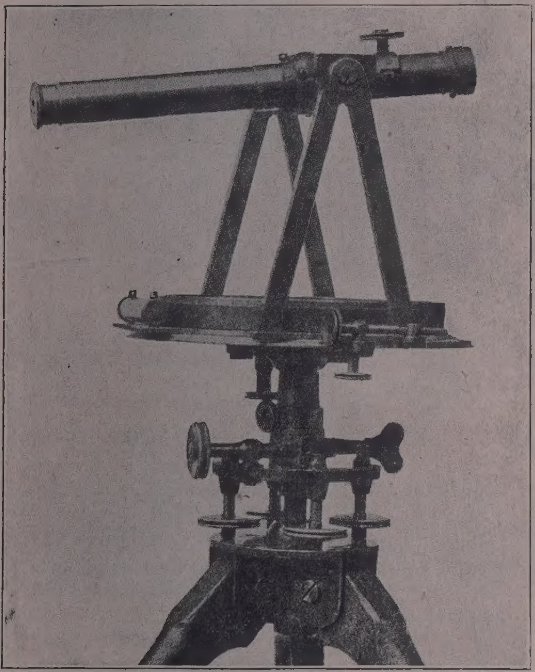


Fig. 1.—The First American Transit.

One excuse for the common practice of furnishing transits with smaller vertical than horizontal circles is found in the supposed danger of injuring the larger size circle. The speaker's experience under the most trying circumstances, incidental to rugged mountain climbing, would indicate that this danger is greatly overestimated. In fact, if the circle is protected with a cast metal guard (and it always should be so protected), there can be little danger. Another solution for this problem, provided the engineer is willing to forego a complete vertical circle, is found in a device described by Mr. Walter L. Webb, consisting of a short arc of very large radius provided with two verniers whose zeros are exactly 60 deg. apart. The graduated arc, attached firmly to the telescope axis, is numbered in two rows from 0 deg. to 60 deg. each way. For elevated reading (plus) the right hand vernier is used, while for depression (minus) angles the left hand vernier is read. Such a device readily allows of an arc of 7 in. in diameter which would insure ease and certainty of its readings to half minutes. This device is more clearly shown by Fig. 3, taken from Mr. Webb's paper, above referred to.

Whether an arc or a circle be furnished, its vernier should be provided with an accurate and easy method of adjusting the zero, preferably by means of a slow-motion screw.

One objection to the substitution of the vertical arc for the complete circle is that it precludes the reversion of the circle for the elimination of errors of adjustment in such problems as, for example, the determination of azimuth by the direct solar observation, now so commonly used in the West. Although the small vertical circles generally furnished by makers ostensibly read to single minutes, experienced observers are well aware that this accuracy is seldom realized, because of the uncertainty of the reading. Such circles should be graduated to half minutes and provided with permanently mounted magnifying glasses.

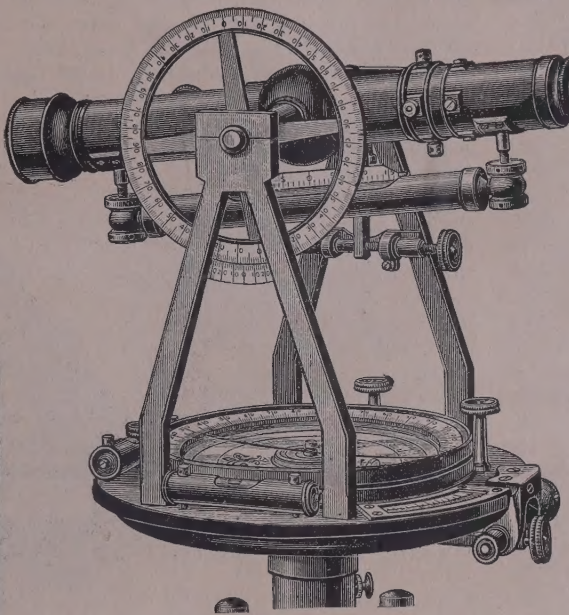


Fig. 2.—Engineer's Complete Transit Tachymeter.

The second element which introduces error into the vertical work of a transit is the common practice of depending upon cheap non-sensitive plate levels for the control of the vertical circle zero. If not specified, makers send out plate levels with a sensitiveness between 100 and 360 seconds per one-tenth inch of level. It is common knowledge that after the orienting backsight has been taken and before the foresight can conveniently be taken, the instrument will get out of level, a condition indicated by the plate bubbles getting off center. This introduces errors in the vertical circle readings, it may be of equal angular amounts. Nor can the plate levels be revealed without increasing the error in the orientation which will affect all subsequent azimuths. But even if this displacement does not always take place, a sensibility of 100 to 360 seconds is quite inadequate to control the vertical circle. The remedy for this evil is found by placing an extra level on the vertical circle guard to which is also rigidly attached the vertical circle verniers. The vertical circle guard is made to rotate about the horizontal axis of the telescope by means of a slow motion screw, so placed as to be impossible of confusion with the gradienter screw. The extra bubble is first adjusted to a central position when the vertical circle verniers read zero, the big telescope level bubble being also central, and the line of sight horizontal. Now if the horizontal plate gets out of level, the true vertical angle to the forward point can still be read by simply turning the slow motion screw until the extra level bubble comes to the center of its tube. The vertical circle reading is now the true vertical angle. A view of such a device is shown in Fig. 4. The speaker advocates two double verniers on the vertical circle, even if the second vernier is used merely to check eccentricity. The entire vertical circle should be protected by the guard, the verniers being covered by glass windows, the same as the verniers on the horizontal limb.

A third suggested change in the construction of the telescope has for its object suitable provision for making the optical center of the object glass describe a straight line coincident with the geometrical and optical axis of the telescope. This requirement is often lacking and yet without it the other specifications will fail to insure accurate work. The most frequent causes of the failure of the above requirements are due to either too short an object-glass slide or to the imperfect or inadequate fitting of its movement. This point is discussed more fully under the head of the wye level.

A fourth needed change in the design of the transit, and one certain to improve the accuracy of its vertical work, is found in a rational increase in the sensibility of its telescope level.

Except in very mountainous regions a properly run topographic traverse by the "transit and stadia method" allows a considerable proportion of the vertical angle readings on turning points to be replaced by level readings, thereby correspondingly reducing the amount of required office work, while at the same time insuring a higher degree of accuracy in the resulting levels. This would notably be the case in a combined hydrographic and topographic survey of a river and its adjacent valley. This point was first brought to the speaker's attention while making a survey of the Colorado River for a distance of about 25 miles near Yuma, Ariz. At this point the river flows in a wide sandy valley of light gradient so that practically all elevations were taken by level readings. Although this survey was executed under the most trying conditions of desert weather, and with an average length of sight of about 1,000 ft., the levels checked on bench marks determined by accurate spirit leveling within one half a foot in the 25 miles. Even closer results have since been observed on topographic lines, which lead the speaker to the conclusion that a properly devised level on the transit telescope is quite sufficient to secure results under favorable circumstances comparable to that of common wye levels, and expressed by the formula, error = 0.05 ft. x the square root of distance in miles as the highest limit, and perhaps twice this for the lowest limit, the latter being expected only under very unfavorable circumstances of length of sight and weather conditions.

If the above statement of the accuracy of transit levels be accepted as true, and a fast increasing number of topographers are accepting it, the field for the engineer's wye level is small indeed. However, such high grade work cannot be expected with transits furnished with a non-sensitive and irregularly ground level so frequently furnished the unsuspecting purchaser. After considerable experimental work to determine this point, the speaker suggests a sensibility corresponding to one-tenth inch equal to twenty seconds of arc. Of course the sensibility of the levels and the magnifying power of the telescope are inter-related.

Other important requisites of a rationally designed engineer's transit, not always complied with, may be considered under the following heads: (a) Magnifying power, (b) chromatic and spherical aberration, (c) definition, (d) flatness of field, (e) illumination, (f) centering of lenses. The limits of this paper will allow only a very general treatment of the above points. Preliminary to testing a transit, the owner would do well to look carefully into the telescope barrel through the objective in order to discover the presence of an interposed diaphragm, sometimes inserted by the maker to prevent the discovery of the many evils resulting from poor lenses and poor workmanship.

Such a diaphragm should not be tolerated, because it must reduce the effective diameter of the objective correspondingly, and thereby seriously interfere with its function as a light gatherer. The presence of such a diaphragm may always be taken as prima facie evidence of poor workmanship, unless inserted near the reticule.

For the ordinary transit, the magnifying power has been considered sufficient if a movement of the alidade corresponding to the least count of its vernier causes an easily perceptible movement of the line of sight on the object sighted. For stadia readings this magnification is insufficient, since the characters on the rod must be accurately read. It must be remembered, however, that high magnification is at the expense of the size and brightness of the field. This loss in brightness must be compensated for by providing a larger size objective. As this in turn makes necessary a longer telescope, the resulting height of standards required to allow the telescope to "transit over" limits the size of the objective. This difficulty can be overcome in part by the use of an inverting eye piece. The speaker is well aware that in advocating an inverting eyepiece, he is opposing the usual custom of this country. But here, again, we are behind our European brothers. The opposition to an inverting telescope in most part rests upon prejudice. A thorough trial of the inverting telescope is certain to result in a verdict establishing the superiority here claimed. The speaker knows of scores of converts thus made. The most important advantages of the inverting eyepiece are the following: 1. It largely increases the brightness and distinctness of the image. 2. It allows for a shorter telescope for any given magnification insuring a more rigid and compact instrument.

The flatness of the field depends largely on the sphericity of the eyepiece. This may be tested as follows: Draw a heavy lined square 8 in. on a disk and place it at such a distance from the instruments that it shall nearly fill the entire field. When the telescope is focused its side should appear perfectly straight, though a slight curve at the extreme limits of the field should cause no appreciable error in stadia work.

The definition of a telescope depends upon three conditions, the accuracy of the curvature of the various lenses, upon their centering and upon their movement in focusing. If the eccentricity of the eyepiece is large or if the optical axis of the lens be not parallel to the line of sight, the definition may be so poor as to seriously affect the focusing of the extreme stadia wires. Displacements of the objective are even more serious in producing poor definition of the image.

Lateral displacements of either eyepiece or objective may be discovered by taking the telescope of the transit out of the standards, and, after focusing the threads and objectives on some distant point, turn the telescope in improvised wooden wyes. The image and the threads will appear to move in the arc of a circle above the telescope axis even when the wire or reticule adjustment has been perfectly made. Not infrequently makers send out even wye levels whose lenses, when tested as above, show very large eccentricities. Such an instrument should be promptly returned to the maker.

The following specifications for an engineer's complete transit are those used by the University of Wisconsin:

General Conditions.—All constructive details shall be of superior workmanship and design. Weight not essential to the stiffness of the instrument shall be avoided by the standard rib construction. The instrument without tripod should weigh not more than 10 lb. Especial attention shall be given to making extra strong all parts likely to be injured by accident. Only the hardest bell metal and phosphor bronze shall be used for centers and telescope axis, and soft brass shall be everywhere avoided. Tangent screws and head of tripod shall be made of aluminum bronze and provided with German silver spiral springs. Prices shall be f. o. b. Madison, Wis.

Horizontal Circle.—The diameter at the edge of graduation shall be 5 in. The graduation shall be to half degrees on solid silver, frosted finish, and every 10 deg. shall be distinctly numbered from zero to 360 in both directions, the numbers sloping in the direction they are increasing. The circle shall be provided with two double verniers, *A* and *B*, exactly 180 deg. apart, and reading to single minutes.

The zero of the verniers shall be placed at an angle of 35 deg. to the line of sight, and shall be provided with ground glass reflectors. Eccentricity of vertical axis and of all verniers must be as perfectly eliminated as the highest mechanical skill will allow.

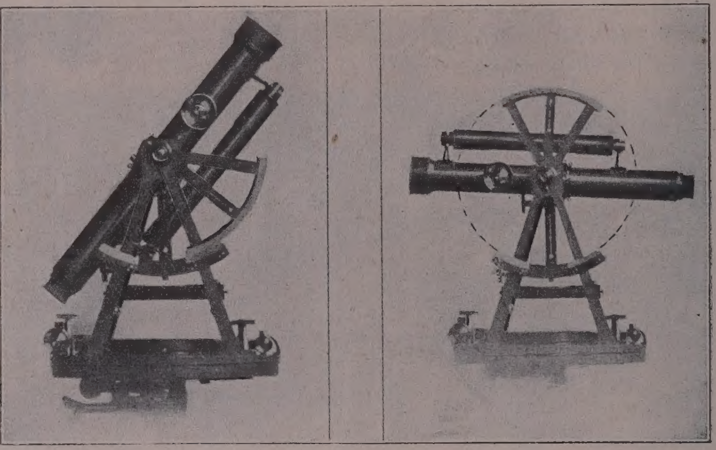


Fig. 3.—Transit Fitted with Long-Radius Arc.

Complete Vertical Circle.—Transit shall be provided with a complete vertical circle with a diameter of not less than 5 in., graduated on solid silver and read to single minutes by two double verniers. The verniers shall be provided with an easy and reliable means of adjustment. The vertical circle shall be furnished with a cast metal guard to protect the entire edge of the graduation. An extra level, sensibility 0.1 inch = 20 seconds, with suitable means of adjustment, shall be firmly mounted on this guard so as to control the zeros of the verniers. The horizontal axis shall have a radial clamp and slow motion screw with a gradienter.

Magnetic Needle.—Instrument shall be provided with the usual compass box and a sensitive and accurate needle about 3½ in. long.

Telescope.—The objective shall have a clear aperture of not less than 1⅜ in. in diameter, perfectly achromatic and with a flat field, suitable for accurate stadia measurements. Both the objective and ocular lenses shall be mounted so that their optical centers lie in the geometrical center of telescope tube, and provision shall be made to insure that the optical centers when focused shall describe a straight line, the prolongation of the optical axis. The eyepiece shall be inverted and magnifying between 24 and 28 diameters and be free from chromatic aberration. It shall also be provided with a prismatic eyepiece with a solar shade. The regular eyepiece shall have the usual focusing screw or worm and a dust guard. The horizontal axis of the telescope shall be provided with the most improved means of adjustment and shall be fitted with a suitable base for the attachment of a Saegmuller solar attachment. Two extra fixed stadia wires, very fine and opaque, shall be furnished and placed equidistant from the middle cross-wire. The total distance apart of the stadia wires shall be 1/100 of the focal length of the objective. They shall be of such size as not to cover more than 0.02 ft. on a rod held at a distance of 1,000 ft.

Telescope Level.—The level shall be ground to a uniform curvature of 0.1 inch = 20 seconds. The graduations shall extend over the entire exposed length and shall be numbered on the vial both ways from zero at the center.

Plate Levels.—Both plate levels shall be accurately fixed to the transit with the most approved and stable provision for their adjustment. Both levels shall be graduated and their curvature shall be 0.1 inch = 40 seconds.

Clamps.—The heads of all clamps shall be one-third smaller than usual pattern to prevent injury from inexperienced hands.

Finish.—The telescope, telescope level, vertical circle guard, and standards shall have the so-called "cloth finish," the remainder any good standard finish.

Tripod.—The tripod shall be of split leg pattern and provided with shifting center. Its weight shall not exceed 7 lb. The steel shoe of tripod shall be provided with a shoulder for forcing it into the ground.

Box.—The instrument shall be furnished in a neat hardwood box with lock, together with a sun shade, reflector, magnifying glass, plumb bob, wrench, adjusting pins, and silk or waterproof bag. The box shall have a leather strap and rubber cushion on the bottom, and shall be so constructed as to allow of transit being packed flat instead of upright.

A discussion of the relative merits of "wye" and "dumpy" levels is aside from the main purpose of this paper, and yet it may not be out of place to briefly state the speaker's views on this point. The American engineer is clearly behind his European brother, who has long recognized the merits of the dumpy type of leveling instruments. The greater steadiness claimed for the wye level is more than offset in the dumpy level by its simplicity of construction and adjustment, with the resulting certainty of the relation between the line of sight and the axis of the level vial. The supporters of the wye level have little ground on which to stand. The most perfectly constructed leveling instrument ever made, both from the theoretical standpoint, as well as evidenced by its completed work, is the latest type of precise level designed by the U. S. Coast and Geodetic Survey. This level is of the dumpy type. With it 250 miles of single level lines have been run per month, and that, too, with greatly increased accuracy over that claimed for commercial leveling. The merits of the dumpy level are already proved and its general use will be delayed only by the difficulty of "teaching old dogs new tricks."

The following brief discussions include the important points in the University of Wisconsin specifications for a wye level:

Telescope.—(a) The object glass should have clear aperture of not less than 1⅜ in. and should have the other requisites given in the discussion of the transit. It is doubly important in the level that the object glass should be so securely and accurately mounted that when focused at different distances its optical center shall describe a straight line coincident with the geometrical axis of the telescope. Any wabbling is fatal to accurate work, since the line of sight will not remain parallel to the level axis, the most important relation in a level. Stable conditions can be best secured by the use of long object glass slide, extending nearly to the reticule. In general it appears that this detail is most often slighted by the makers.

(b) It is imperative that the diameters or the rings or collars should be the same if the axis of the bubble is to be made parallel to the line of sight by the "indirect method." The possibility of making the above adjustment by the indirect method is sometimes given as one of the arguments for the use of the wye level, and yet if the diameters of the rings differ by 1/5000 part of an inch the resulting error in a rod reading 300 ft. distant would amount to about 0.01 ft. even when the instrument appeared to be in perfect adjustment.

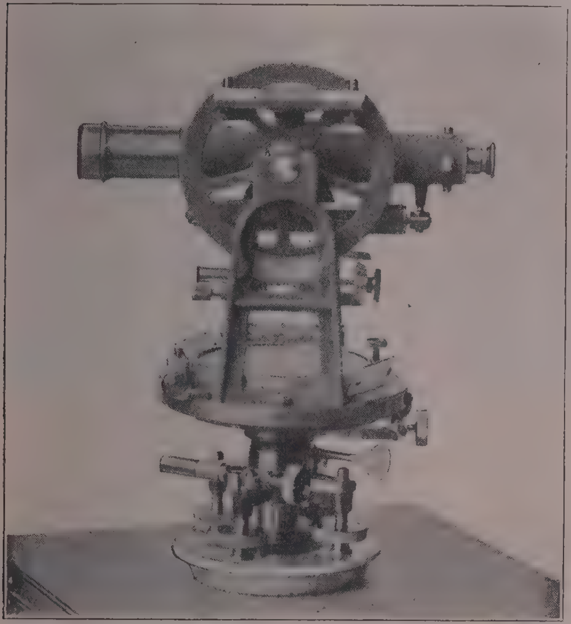


Fig. 5.—Instrument Made in Germany.

(c) The eyepiece should be inverting, magnifying 35 diameters, and protected by dust shade.

Level Vial.—The level vial should be carefully ground to a uniform curvature of 1/10 in., equal to 8 to 10 seconds of an arc. The graduations should be etched on the bubble tube itself and not attached to a scale as is frequently done. Care must be taken to have the pitch of the leveling screws correspond to this sensibility or the position of the bubble cannot be readily controlled.

Clamps and Tripod.—A clamp and slow motion should be provided to the vertical axis. The small extra charge for the clamp and slow motion to the vertical axis is well worth the cost. Tripod specifications are similar to those of the transit with this addition. The accuracy of any work is in large measure dependent upon the mental state of the observer. If he can observe in a comfortable position in the long run his work will show increased accuracy over that performed under uncomfortable circumstances. For this reason it would be well to have the length of the tripod legs increased so that the engineer could observe in a nearly upright position. If a tripod be provided like that of the U. S. C. & G. S. precise level, no unsteadiness will result from this increased length. Frequently it would be convenient if instrument makers would provide interchangeable tripods so that both the transit and level would fit on the same rod.

Finish.—The felt finish should be specified on telescope and level vial.

Dumpy Level.—The only modifications in the specifications suggested in the dumpy level would be to increase the magnifying power to 30 diameters and the sensibility of the level vial to 0.1 inch = 12 to 15 seconds of arc. The eyepiece should be inverting.

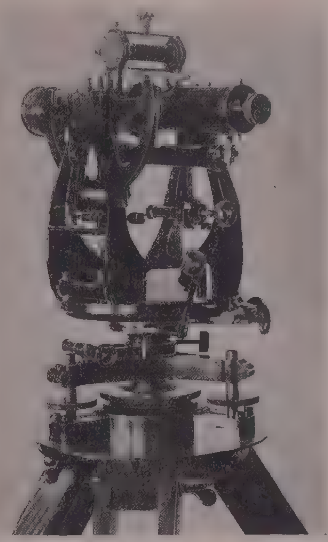


Fig. 4.—Showing Extra Level on Vertical Circle Guard.

The university has paid $75 for the above described instrument. The average accuracy of the leveling work done at the university by sophomore students is 0.035 ft. into the square root of the distance in miles. This is the error determined by the closure of circuits about 5 miles long.

The present type of "dumpy" level made in this country would be greatly improved by the adoption of the improvements made on the new U. S. Coast and Geodetic Survey precise level. Briefly stated these are as follows:

(a) A micrometer for making the final pointings of the line of sight after the level is approximately level.

(b) Inserting the more sensitive level vial in the top of the telescope and as near to the line of sight as possible.

(c) The use of a reflector which will allow a view of the level bubble at the same time as the rod reading is made.

That there may be no doubt regarding the need of definite specifications similar to the foregoing, it may be said, that before this plan was adopted at the university, the instruments were seriously lacking in important details. For example, one of the oldest and best known American firms furnished a transit whose telescope level had a sensibility of 0.1 inch = 360 seconds. (suitable for a hand level), and whose plate bubbles had a sensibility of 0.1 inch = 360 seconds. Though the horizontal circle of this instrument is nearly 7 in. in diameter, the vertical circle furnished has a diameter of only 4 in. The results obtained by this instrument have shown a uniformly larger error than that attained by the standard instruments purchased under the above specifications.

A comparison of the plate bubbles of ten similar instruments purchased simply by catalogue number, shows that not only do different firms use widely different levels on the same grade of instrument, but even the same firm does at different times; the range on plate bubbles being from 46 to 360 seconds, and on telescope levels from 8 to 72 seconds per one-tenth inch division. The conclusion, that makers frequently use whatever they happen to have in stock, quite regardless of suitability, seems warranted by facts. Some will not fail to urge the impossibility of buying a transit at a reasonable price under such rigid specifications as suggested above. In answer it can be said that the average price paid for a transit under these specifications has been considerably less than formerly, without specifications. It should be said, however, as bearing on this point, that the later contracts have called for larger numbers of instruments. The present year the lowest bid, from an American maker, was $175 per transit. The university owns several transits made by this maker, and severe field tests have shown them the equal of any, both in accuracy and durability. The transit, shown in Fig. 5, was purchased of a German firm. It cost, delivered in Madison, about $136, being admitted duty free. This instrument would cost about $225 in this country. Repeated tests of this type of instrument have shown it equal both in accuracy and durability to any made in the United States belonging to the university.

High Pressure Gas Distribution.

High pressure gas distribution as practiced by the Western United Gas & Electric Co. presents several interesting features. The company supplies, according to Mr. H. L. Rice, 24 cities and towns west of Chicago, having a population of about 140,000 and situated along a line 52 miles in length between extreme centers of distribution. There are coal gas plants at Joliet, Elgin and LaGrange, which pump their surplus output into the pipe line, and a combination coal and water gas plant at Aurora puts into or takes from the line, according to pressure conditions. With compressors pumping at the four extreme points of the line, a pressure of 15 lb. is maintained everywhere; the line has been tested everywhere for a pressure of at least 60 lb. There are 83 miles of this high-pressure main, 275 miles of low-pressure distributing pipes and 50 miles of high-pressure distributing pipes. The most interesting feature of the system is the proposed concentration of all manufacturing at Joliet, making all consumers outside of that city dependent on the high-pressure main. Starting with 50 lb. pressure at Joliet it is expected that there will be not over 10 lb. drop in the 8-in. main to Copenhagen, 16½ miles distant. From this point a 6-in. main runs to Aurora, 7½ miles distant, and here 10 lb. more drop is believed to be an ample allowance. From Aurora a 5 and 4-in. line runs to Elgin, 23 miles distant, and here repumping will be necessary unless the pressure at Joliet is more than 50 lb.

The Treacherous Character of Clay found in the vicinity of Pittsburg is shown by an experience with a retaining wall recently mentioned by Mr. Willis Whited. This was about 11 ft. high and 13 ft. thick, built of good concrete and carried down to a good foundation. In spite of its ample dimensions when figured by any of the customary rules for retaining walls, the pressure of the clay sheared off the wall. Mr. Whited states further that he has seen clay slides which came to the surface at a natural slope of about 13 deg.

Waterproofing at the Subway Power House, New York.

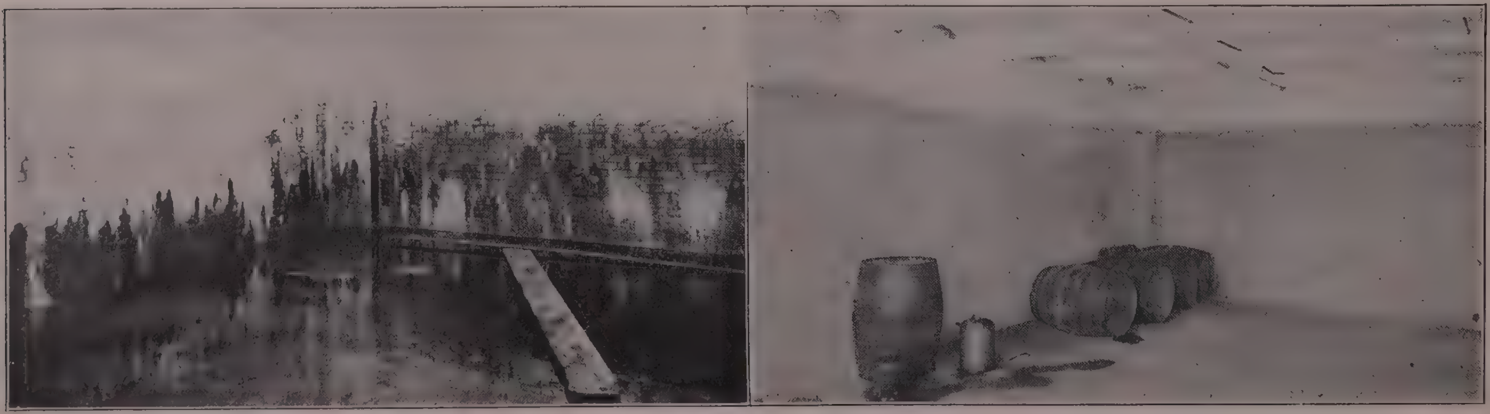
For the last six years the Winslow method of waterproofing cellars and walls exposed to dampness has been followed by a firm of Chicago contractors. Although it has been successful it is practically unknown outside of Chicago and New Orleans, and the following notes of its use in the basement of the 59th St. power house of the Interborough Rapid Transit Co. in New York are accordingly given here. The work was done at a corner of a basement not far from some large gas-holder tanks across the street, which kept the ground thoroughly saturated with water. Although the walls of the power house were built of 4 ft. of good brick in cement mortar, waterproofed on the outside with some tar preparation, they leaked in many places. They were originally whitewashed, and the infiltration of water from the outside, carrying tarry matter with it, soon produced the appearance shown in the first of the accompanying illustrations. The odor from this water was very offensive, and this portion of the basement was so wet as to be practically useless. The conditions were so bad that the Waterproofing Co. of New York, a branch of the Foundation Co., decided it would be a good place in which to try the new system of waterproofing, using "hydrolithic coating," as it is called. They secured permission to apply the process to a short section of the wall, and the result was satisfactory. This test strip, 6 ft. high and 22 ft. long, kept the basement near it so dry that it was selected as the best place for the storage of extra grate bars for the stokers of the boiler plant. The Waterproofing Co. was then given a contract for the remainder of the waterproofing needed.

It is necessary to have the surfaces to which the coating is applied perfectly clean, so that it will adhere to them, and it is desirable for the same reason to rake out the mortar in the joints of the brickwork, as in pointing. The problem of waterproofing by means of a coating applied to the inner surface of a wall is very different from that of waterproofing the exterior surface, where the protective material is pressed against the masonry or concrete, and consequently in the former case the surface must be carefully cleaned. In this particular instance the work was done with a pneumatic tool, and the accompanying illustration of the men at work at the power house basement shows at the right one of the workmen cleaning off the wall in this way. The streaks on the wall near where he is standing are the streams of discolored water flowing through holes drilled into the wall, for the insertion of tubes which serve to concentrate the flow until the coating has set, after which these holes are stopped with hydrolithic cement.

After the wall was thoroughly cleaned it was covered with a liquid wash and then with the hydrolithic coating. The work was done with a gang of inexperienced masons, for the restrictions of the labor unions prevented employing skilled men from other cities. Inasmuch as the success of such waterproofing depends on thoroughly conscientious workmanship as well as on the materials used, it was necessary to coach this gang considerably before the work was properly done. Eventually, however, they waterproofed over 400 sq. yd. of very wet wall with complete success. After the work was completed there was but one slight leak in it, at the corner of the plaster in the angle of the wall. This was stopped without any difficulty, as cracks in the hydrolithic coating, provided there is no failure of adhesion between coating and wall, can be repaired easily. The success of the operations is shown by a comparison of the views taken in the basement before and after the work.

Method of Applying waterproofing in Power Station Basement.

The coating is from $\frac{5}{8}$ to 1 in. thick, depending on the position it occupies and the work it has to do. The company prefers to apply the coating on the inner surface, since by so doing excavation is saved and repairs, if necessary, are quickly made. And what is still more important, with this method of interior waterproofing no furring or plastering is needed, as the walls are left with a smooth finished surface light gray in color. As no supporting walls are necessary, there is a saving in space along all walls of from 8 to 24 in. In crowded sections of cities where land values are great, this saving of floor space in basements and sub-basements is a most important factor in favor of the system. The hydrolithic coating on floors is specially finished on top so as to have a durable wearing surface.



A Corner in the Basement of the New York Subway Power Station Before and After Waterproofing.

Early German Steam Engines.

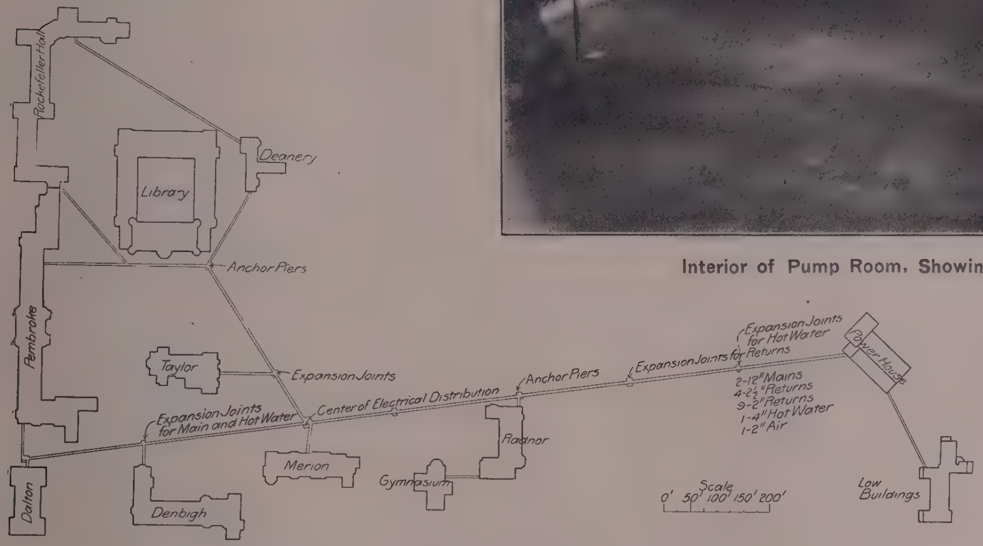
Early German steam engines form the subject of an interesting paper by Mr. Conrad Matschoss in the "Zeitschrift" of the Society of German Engineers. The first engine was apparently built by a Capt. Weber from plans procured by him in England. It was apparently a pump of the Savery-Pupin type and was constructed in 1715 at Cassel. Apparently it was not long in use, and assertions to the contrary have apparently been due to a confusion of the engine with another constructed in 1722. The latter was built by Isaac Potter under the direction and with the technical assistance of Baron von Fischer, an architect and engineer. It was a Newcomen engine and its duplicate was erected at the same time by them at Vienna. The first of these machines remained in service until 1768, and another built about the same time by Potter for a colliery near Koenigsberg, Hungary, is known to have run without interruption for more than two years. A Savery engine was built in St. Petersburg for the Czar about 1717.

The Heating and Lighting Plant at Bryn Mawr College.

By George C. G. Gray.

During the summer and autumn of 1902, there was installed at Bryn Mawr College, Bryn Mawr, Pa., a central heat, light and power plant, which had become a necessity on account of the rapid growth of the institution. The old plant, which has been lost sight of entirely in the present installation, was composed of three separate boiler units, of 350, 150 and 100 h.-p. capacity, respectively, and supplied steam for the heating of the following buildings of the college: Pembroke Hall, East; Pembroke Hall, West; Dalton Hall, Denbigh Hall, Merion Hall, the Gymnasium and a small portion of Radnor Hall. The remaining buildings, viz.: Taylor Hall, Low Buildings, The Deanery, Yarrow Cottage, Keiserhof Cottage, and the greater part of Radnor Hall, were heated by hot air furnaces. The locations of these buildings are shown in the plan of the grounds. Yarrow Cottage and Keiserhof Cottage are not shown, having formerly occupied part of the site of the Donor's library, now almost completed, and were moved to make room for this building. They have been joined together to make one building, and are now known as Yarrow East and West. Their location is at the extreme western end of the grounds. All the buildings previously mentioned were lighted by gas and oil lamps until the installation of the new plant.

The power house is situated at the lowest part of the grounds, which makes it possible for the water of condensation from the heating systems to be returned by gravity from all the buildings with the exception of Rockefeller Hall, The Deanery, and the Library; as the ground has a slight fall toward these buildings it is necessary to use motor-driven pumps to raise the water of condensation from them to the highest point on grounds, from which point it flows by gravity to the power house. The power house building is of red brick with pebble-dash finish. The roof is carried on steel trusses, and is lined inside with corrugated galvanized sheet iron. All the floors are of fireproof construction supported on I-beams and tin lined fire doors have been provided between the engine room, boiler room and pump room in order to make the building as nearly fireproof as possible. The coal bin extends the full length of the boiler room and has a capacity of 1,000 tons. There is an opening in front of each battery of boilers, so that the coal can be handled with the minimum amount of labor. A suitable roadway has been provided which allows the coal wagons to drive directly on to the top of the coal bin and dump the coal into the bin without handling.



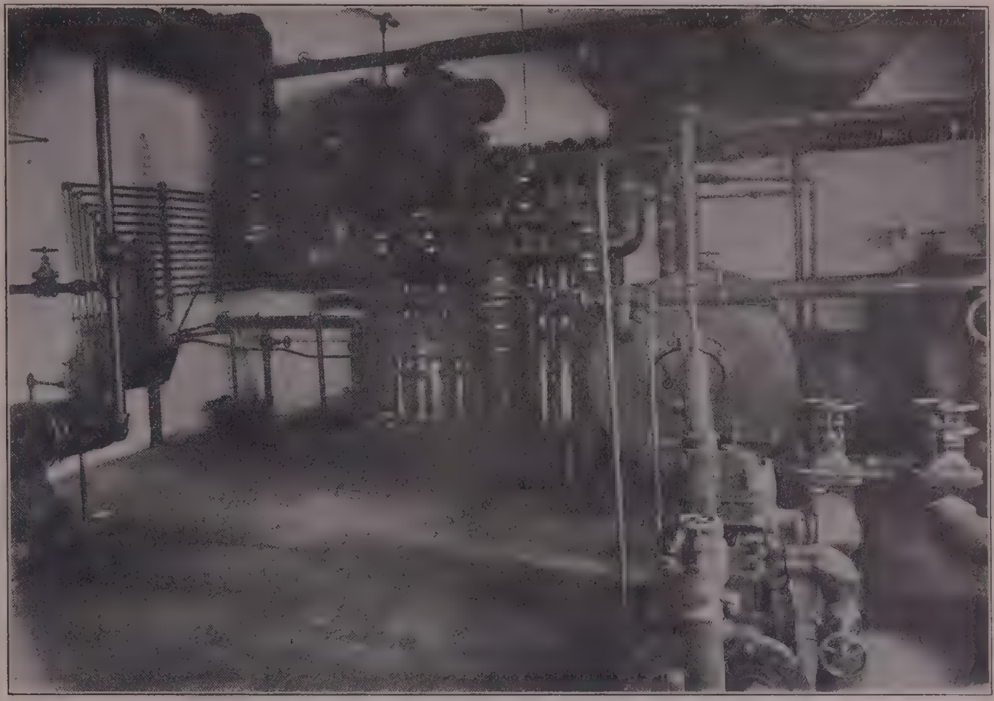
Arrangement of Piping Tunnel, Bryn Mawr College.

There are eight boilers of the horizontal return tubular shell type, each 72 in. in diameter by 12 ft. long, containing 134 3-in. tubes. They are set in four batteries of two each, in a very substantial manner, the buckstays being heavy I-beams shown in drawings of the settings. It will be noticed that the boilers are suspended from I-beams spanning the tops of the settings instead of being supported by lugs riveted to the boiler and resting on the side walls, as is usually the case. All the boilers are built for a working pressure of 100 lbs. per sq. in. The plates for boilers were made by Worth Brothers, Coatesville, Pa,. and the boilers were built at the Titusville Iron Works, Titusville, Pa.

Each boiler has two 6-in. connections taken from the 6-in. steam nozzle, one of which is connected to the 12-in. high pressure main, which extends the full length of the boiler room and supplies the engines and auxiliary machinery with high pressure steam. The other is connected to the 12-in. low pressure main, which also extends the full length of the boilers, and which runs direct to the 12-in. header at the entrance to the steam tunnel, where it is joined by 12-in. exhaust pipe from the engine and pump room. It will be seen from the foregoing description that this arrangement of piping allows any of the eight boilers to be operated either on high pressure or low pressure, as desired.

The boilers are hand fired and the draft is entirely mechanical, the smoke stack extending only to the height of the roof of the power house. The draft is furnished by a steam-driven induced draft fan built by the American Blower Co. and a forced draft fan made by the B. F. Sturtevant Co., which is belt-driven by a 9-h.-p. electric motor, built by Northern Electric Co. The speed of both fans is controlled by a damper regulator, made by the Collins Mfg. Co., Conshohocken, Pa. This combination of forced and induced draft makes possible the economical use of the smaller sizes of anthracite coal for steam making purposes, the coal at present used in the plant being No. 2 buckwheat, generally known as rice coal.

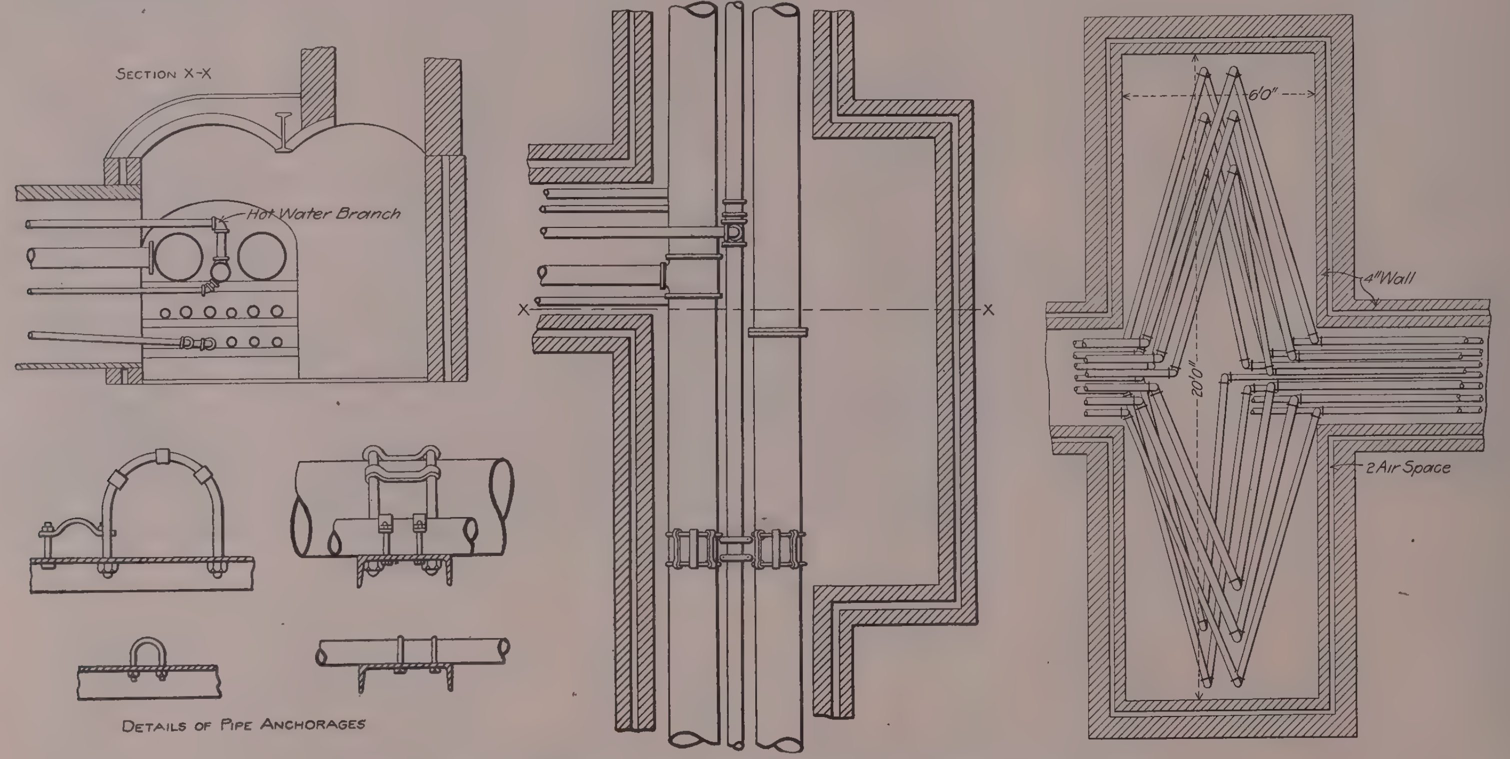
It will be seen from the cross and longitudinal sections of the boiler settings, that the arrangement of the flues and ducts is somewhat novel and out of the ordinary in general practice. The smoke flue is very roomy and easily accessible for cleaning,—the top of the flue being in line with the top of the boiler settings. Directly under the smoke flue there is a large duct, containing water economizers, which extends the full length of the boiler room, as is also the case with all the other ducts and flues shown in plans and cross-section drawings of boiler settings. The water economizers are of a "home made" type, built of cast iron manifolds and 2-in. wrought iron pipe, with swing joints at each of the manifolds to allow for expansion. They extend the entire length of the duct, as shown in the basement plan of the boiler room, there being two separate banks of economizers in the same duct. The one supported on the outside wall of boiler settings is made up of galvanized pipe and fittings and is used in heating the water used for domestic purposes in all the college buildings; the other economizer, supported on the boiler side of this duct, is made up of plain cast iron fittings and wrought iron pipe of the same dimensions throughout, as the domestic water economizer, and is used to raise the temperature of the feed water for the boilers. The economizers are fitted with valves for blowing out any sediment that may lodge in them and with by-pass valves arranged so that economizers may be cut out of service at any time for repairs. They are also provided with safety valves set at 125 lbs.



Interior of Pump Room, Showing Pipe Connections to Tunnel.

Again referring to the basement plan of the boiler room it will be noticed that there is a large duct running parallel with the water economizers, and containing 56 lines of 6-in. stove pipe. These pipes run into a chamber at the extreme end of the boiler room, which is connected to the air distributing duct, shown directly under the ash-pits. The air from the forced draft fan is driven through these pipes on its way to the ash-pits and as the hot waste gases are passing around the outside of the pipes for the entire length of boiler room, a great deal of heat is taken up by the air from the forced draft fan as it passes to the distributing duct under the ash-pits. The temperature of this air at the ash-pits ranges from 150° to 200° F. In the main smoke flue there is a large damper at the stack end, for the purpose of directing the waste gases either into the stack or through the economizers. There are also dampers at the forced draft fan and at the end of the air economizer duct which when closed allow the air from the forced draft fan to by-pass directly into the duct under the ash-pits.

In following the path of the gases from the boilers to the induced draft fan, by stages, it passes, 1st, From settings into main smoke flue at the rear of the boilers; 2nd, downward into water-economizer section of the induced draft duct, directly under main smoke flue, and 3d, back through air-heating flue duct which is connected to the induced draft fan by which they are discharged to smoke stack. The temperature taken in the several flues and of the water and air heated by the waste gases will be found in the record of a 24-hour test of the plant which accompanies this article.



Details of Pipe Tunnel Construction, Showing Anchorage and Expansion Joint Manholes.

The boilers are fed through either one of two feed lines, there being two feed valves to each boiler, one connected direct to the feed pump line from the economizers and the other to the street service line, which, owing to an elevated reservoir supply, delivers a pressure of 90 lbs. per sq. in. at the power house. There is also an elaborate and well arranged system of by-passes between these lines which makes it possible to feed water to the boilers in four different ways. There has also been a connection made from the swimming pool in the Gymnasium to the power house, so that in case of possible failure of the water service, the water in the pool may be utilized for the operation of the plant; this pool contains 60,000 gal. All the boiler feed and other piping is located in a passageway or duct beneath the firing floor of the boiler room, where access for inspection or repairs is easy and from which connections were easily made to the boilers. Each boiler has a 2-in. blow-off which connects from the rear of the shell to a common 2½-in. header in the duct below, leading out to a drain. Compressed air is also piped to every boiler for cleaning flues, as well as water for wetting ashes. The boilers are fitted with American pop safety valves set for 100 lb. per sq. in. Their fronts are of a plain and substantial design and the boiler room is, it will be noted, well lighted and ventilated.

The engine and dynamo room is located at one end of the boiler room and at right angles to it. The walls are lined with buff colored brick and the floor is of cement on I-beams and brick arches. All steam, exhaust and drip piping and also cables from the dynamos to the switchboard are located in a roomy cellar under the engine room and are easy of access at all times.

There are two direct-connected units for the generation of current for lighting and power. The large unit is made up of a McEwan engine, built by the Ridgway Dynamo & Engine Co., Ridgway, Pa., and a Western Electric Co. direct-current generator of 150 kw. capacity at 250 volts. The engine has a cylinder 20 in. in diameter by 18-in. stroke and operates at 200 r.p.m. The smaller generating set consists of similar units, the engine with a cylinder 15 in. in diameter by 14-in. stroke and running at 275 r.p.m., which is direct-connected to an 80-kw. generator also wound for 250 volts.

The electric distribution is on the 3-wire system, a compound wound compensator or balancing set being attached to the neutral cable, to take care of differences in load between the two sides of the system. This method of electrical distribution has many advantages in a plant of this kind. It makes it possible to run a three-wire system with one dynamo, or to run two or more dynamos of different capacities in parallel. It also allows of running motors at 220 volts, while at the same time giving 110 volts for lighting. With a three-wire system at 220 volts much smaller cables may be used than with a two-wire 110-volt system—this is a considerable item in a plant of this class where the buildings to be supplied with light and power are scattered over a considerable area of ground—and again it allows of the use of the very efficient 110-volt lamp as against the uncertain life of lamps of higher voltage.

The switchboard consists of five panels of Vermont marble and was made by the Crouse-Hinds Co. It is fitted throughout with Weston station meters and I. T. E. circuit-breakers. There are at present two sets of feeders running to a center of distribution near the middle of the campus, from which point cables run to all the buildings, thus ensuring a uniform drop in voltage. The cables which are lead covered, made by the Safety Cable Co., are laid in terra-cotta conduit and follow the line of the steam tunnels, which can be located on the ground plan. The table attached gives length and sizes of all these feeder cables.

POWER DISTRIBUTION FEEDERS.

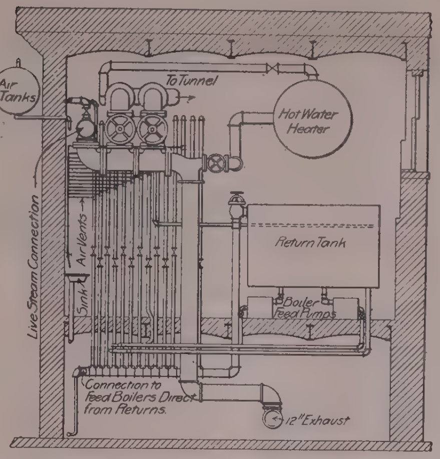
Main Feed—			
4 cables,	700,000 c.m.	1,114 ft.	Main switchboard to center of distribution.
2 "	3/0	1,114 ft.	
Line No. 1—			
2 cables,	500,000 c.m.,	454 ft.	Merion to Radnor.
1 "	2/0	454 ft.	
2 "	350,000 c.m.,	730 ft.	Radnor to power-house.
1 "	No. 1	730 ft.	
2 "	300,000 c.m.,	335 ft.	Power-house to low buildings.
1 "	No. 1	335 ft.	
Line No. 2—			
2 cables,	No. 3	265 ft.	Merion to Gymnasium
1 "	No. 8	265 ft.	
Line No. 3—			
2 cables,	550,000 c.m.,	360 ft.	Merion to Denbigh.
1 "	2/0	360 ft.	
2 "	400,000 c.m.,	336 ft.	Denbigh to Dalton.
1 "	1/0	336 ft.	
2 "	250,000 c.m.,	105 ft.	Dalton to Pembroke.
1 "	No. 2	105 ft.	
Line No. 4—			
2 cables,	No. 1	87 ft.	Merion.
1 "	No. 8	87 ft.	
Line No. 5—			
2 cables,	No. 2	235 ft.	Merion to Taylor.
1 "	No. 8	235 ft.	
Line No. 6—			
2 cables,	300,000 c.m.,	370 ft.	Merion to Library.
1 "	No. 1	370 ft.	
2 "	No. 3	180 ft.	Library to Deanery.
1 "	No. 8	180 ft.	
2 "	4/0	325 ft.	Library to Pembroke.
1 "	No. 3	325 ft.	
Line No. 7—			
2 cables,	350,000 c.m.,	800 ft.	Merion to Rockefeller.
1 "	No. 1	800 ft.	
Line No. 8—			
2 cables,	350,000 c.m.,	415 ft.	Merion to Library.
1 "	No. 1	415 ft.	

MOTOR LOAD.

Radnor	1	4	h.-p. motor for heating fan
Merion	1	3½	h.-p. motor for heating fan
Denbigh	1	4	h.-p. motor for heating fan
	1	1	h.-p. motor for ventilating fan

Deanery	1	1½	h.-p. motor for heating fan
Low building	1	3½	h.-p. motor for heating fan
Pembroke S. W.	1	7½	h.-p. motor for heating fan
	1	1½	h.-p. motor for ventilating fan
Pembroke	1	5	h.-p. motor for heating fan
	1	1½	h.-p. motor for ventilating fan
Dalton	2	3	h.-p. motors for power
	2	2	h.-p. motor for ventilating fan
Rockefeller	1	2½	h.-p. motor for heating fan
	1	2	h.-p. motor for heating fan
	1	1½	h.-p. motor for heating fan
	1	1	h.-p. motor for ventilating fan
	1	¾	h.-p. motor for ventilating fan
	1	½	h.-p. motor for ventilating fan
Taylor Hall	1	5	h.-p. motor for heating fan
Yarrow	1	1½	h.-p. motor for heating fan

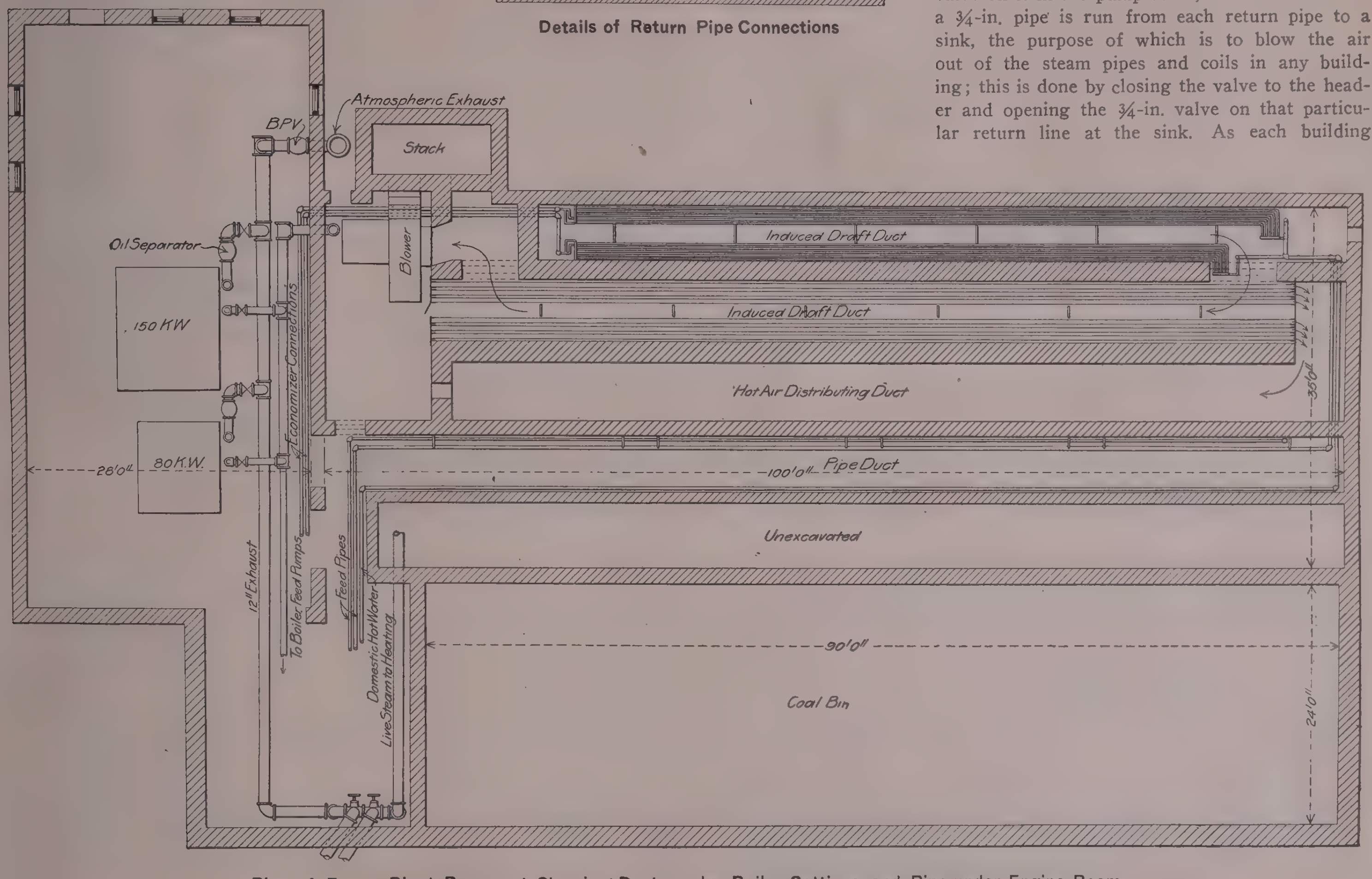
Adjoining the engine room is a pump room, containing the feed pumps, return tanks, the piping carrying low pressure steam to the heating system, a hot water heater and an air compressor.



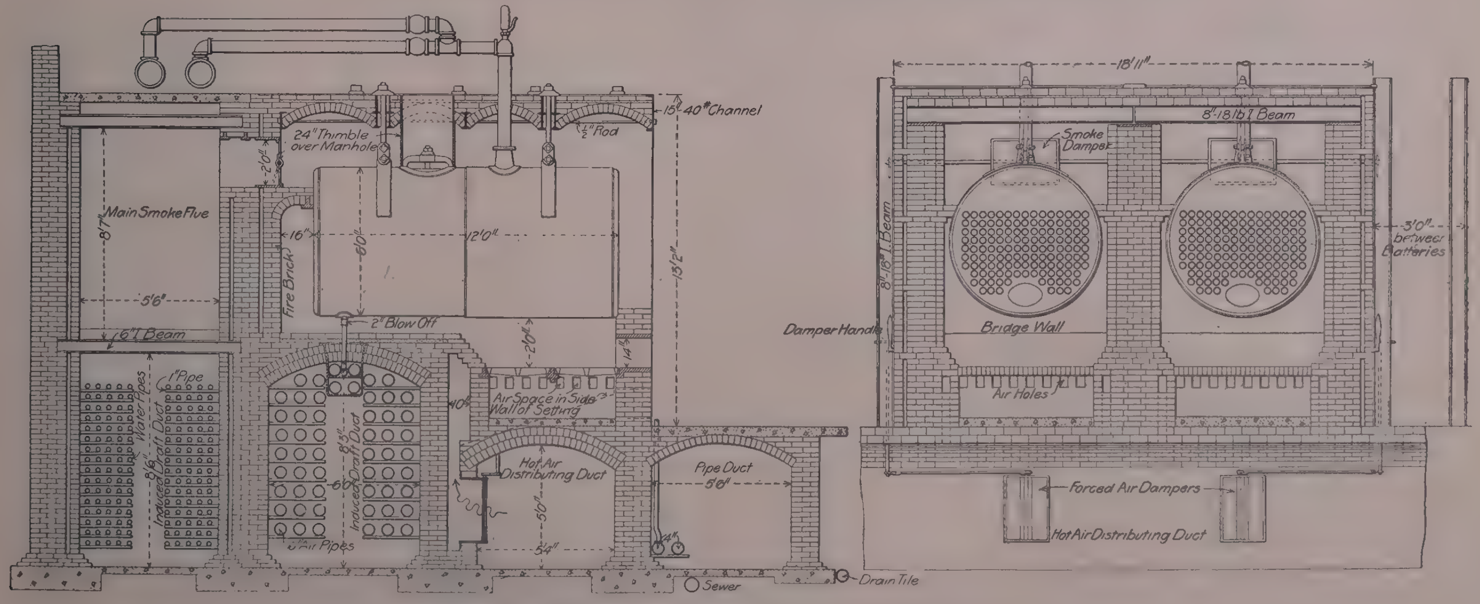
Details of Return Pipe Connections

The arrangement of this piping has been well thought out and will be easily understood from accompanying plan and view of the pump room. The 12-in. exhaust line from the engines and pumps are the 12-in. low pressure line from the boilers, are connected into a common header, out of which two 12-in. lines run to the tunnel to supply the buildings with steam for heating. The return pipes from the several buildings are connected to a common header under the pump room floor, which header in turn empties the return water into two tanks located in the pump room, from which the boiler feed pumps take suction. The return pipes take sufficient drop from the entrance to the tunnel to the return header to allow for a 6-ft. water seal.

It will be noticed that each return pipe has a valve on it in the pump room, above which valve a ¾-in. pipe is run from each return pipe to a sink, the purpose of which is to blow the air out of the steam pipes and coils in any building; this is done by closing the valve to the header and opening the ¾-in. valve on that particular return line at the sink. As each building



Plan of Power Plant Basement Showing Ducts under Boiler Settings and Pipe under Engine Room.



Boiler Settings Showing Economizer and Forced Draft Ducts.

has a separate return to the power house, this arrangement makes it possible to positively blow out any air or entrained water from any building at will. Two Snow duplex feed pumps fitted with Fisher governors are used for feeding boilers, although there is also a direct connection from the return header to the boiler feed line for use if it is desired to operate any boilers exclusively at low pressure for heating. There is also a Clayton steam-driven air compressor, in the pump room, to supply compressed air for the Johnson temperature controlling apparatus in the buildings and a distilling outfit to supply the several laboratories with distilled water.

The hot water for domestic purposes is taken from the economizers, which have already been referred to, and passed under the pump room into the tunnel in a 4-in. galvanized pipe. This line has by-pass connections through a Berryman heater in which the water may be heated if the economizers are out of service for cleaning or repairs. This heater is suspended from the ceiling as may be seen in the view of the pump room. The steam to this heater is taken from the low pressure header and the condensation is delivered directly into the return tanks for the heating system, which are under the heater. The 4-in. hot water main passes into the steam tunnel at the pump room, makes a complete loop of the campus and returns to the pump room, where it is piped to the same sink as the steam return blow-outs and may be blown out in the same manner as described for steam returns. This hot water return is also connected to the return tanks through a Johnson water level controller, thus ensuring a constant water level in the return tanks, as well as the addition of hot water to the return water, to make up for the losses in the heating system. The condensation from high pressure steam main is passed through a Watson & McDaniel high pressure steam trap into the low pressure main.

The flow pipe for the hot water to each building is taken from the top of the 4-in. main, and after making a complete loop through all the hot water outlets in a building is returned into the bottom of the 4-in. main, thus causing a local circulation. This method of supplying domestic hot water has been a great success in this plant. Besides ensuring a constant and plentiful supply, it does away with individual hot water generators in the buildings. A uniformly heated supply in all parts of the system at all times is ensured by the circulating scheme in the main supply pipe and the local circulation circuits in the buildings.

The general arrangement of the steam tunnels will be understood from the plan of the grounds. The steam for heating the buildings is supplied by two 12-in. mains, carrying a pressure of from 5 to 10 lb. per sq. in. Branches are taken to each building from the mains at the nearest point, each branch making a complete circuit of the building to which it is taken and returning to the tunnel, whence it is carried directly to the pump room, as the return for that building only. A manhole has been placed wherever a branch has been taken from the tunnel, which manholes are quite roomy, and will permit of several men working in them, as shown in a cross-section and plan of one of the manholes. The expansion of the steam lines is taken care of by slip expansion joints with brass sleeves placed at intervals of 200 ft. and the pipes are securely anchored to heavy channel irons, built into the tunnel walls midway between each expansion joint. The expansion of the return pipes is taken up by swing joints of ample radius as shown in a detail of one of the expansion joint manholes.

An interesting feature of the tunnel installation is the omission of heat insulation coverings for the steam or other piping entirely. The surrounding air in the tunnel enclosure, was considered to be the most effective insulator, especially as even if the steam piping were covered the temperature of this air would eventually rise to approximate that of the steam line. The walls of the tunnel have been built in two 4-in. thicknesses of brick with a 2-in. air space between and is divided into a number of practically air-tight sections by partition walls which tend to prevent circulation of the air within and confine the heated air for an effective insulation; air leakage is practically impossible owing to a thoroughly air-tight manhole construction and transmission through the tunnel walls is reduced to a minimum by the air space. In case access to any section of the tunnel is necessary, the two nearest manholes are opened and a circulation of cool air established through the section by means of a portable blower, when repairs of any nature to the piping may be made with comfort to the workmen. The amounts of condensation collected from the steam and return lines in the tunnel during a 24-hour test, noted in an accompanying record of tests, are significant of the success of this arrangement.

The heating of the buildings is by the blower system. The cold air is taken into the fan rooms from outdoors, through suitable ducts and is driven by fans over steam heated coils, and through galvanized iron ducts to the rooms. Dalton Hall, the Gymnasium and Infirmary have direct radiation. The fans are driven by motors made by the Northern Electric Co. and Western Electric Co. All rooms and corridors are fitted with the Johnson system of temperature control.

The apparatus for automatically controlling the heating of the buildings, is very ingenious and will be the subject of another article.

The plant was constructed from the designs of Mr. A. D. Houghton, M.E., on whom it reflects great credit. The contractor for its construction was Mr. J. W. Barnes. The brick and mason work was installed by Mr. John Sweatt.

Below will be found a record of a 24-hour test of the plant, also tables showing pressures at extreme ends of low pressure steam mains, which will be of interest.

BRYN MAWR COLLEGE POWER PLANT.

Trial of boilers Nos. 1, 2, 8, connected with heating system, and boilers Nos. 3, 4, 5, 7, connected to large engine and auxiliary machinery, from 7 P. M., Feb. 10th, to 7 P. M., Feb. 11, 1904.

Boilers.	1, 2, 8.	3, 4, 5, 7.
Heating surface of boilers in sq. ft...	1,500	1,500
Grate surface in sq. ft..............	30	30
Ratio of heating to grate surface....	50 to 1	50 to 1
Dry coal consumed per boiler per hr.	294 lb.	383 lb.
Dry coal consumer per boiler per hr. surface per hr....................	294 lb. 9.8 lb.	383 lb. 12.7 lb.
Equivalent evaporation from and at 212° per sq. ft. of heating surface per hr.........................	1.8 lb.	2.3 lb..
Horse-power developed per boiler.....		100
Calorific value of dry coal per pound in B.t.u.	10,600	10,600
Calorific value of combustible per lb. in B.t.u..........................	12,847	12,847
Efficiency of boilers based on coal as fired	80.8%	78%
Efficiency of boilers and apparatus based on feed and domestic water at 40° and air at 22°.............		97.7%
Efficiency of boilers and apparatus based on feed water at 180°, domestic water at 40°, air at 22°.......		96%
Efficiency of feed and domestic water economizers and air economizers....		9%
Average outside temperature........		22° F.

Radiation supplied with steam—
Direct .... 4,200 sq. ft. heating surface
Indirect ....10,440 sq. ft. heating surface
Average electrical load............315 amps. at 240 volts
Domestic water heated.........................330,345 lb.
Coal burned, 50,856 lb., with calorific value of 10,600 B.t.u. per lb. dry coal.

Feed water economizers, domestic water economizers, air economizers and returns from buildings were used during this test.

Duration of trial................	24 hrs.	24 hrs.
Weight of coal as fired..........	18,871 lb.	31,985 lb.
Percentage of moisture in coal....	6.5%	6.5%
Weight of dry coal as fired.......	17,647 lb.	29,906 lb.
Weight of ash	3,741 lb.	6,340 lb.
Percentage of ash in dry coal.....	21.2%	21.2%
Weight of combustible consumed..	13,906 lb.	23,566 lb.
Weight of water fed to boilers and apparently evaporated	162,375 lb.	265,475 lb.
Factor of evaporation............	1.003	1.0363
Equivalent water evaporated from and at 212°..................	162,423 lb.	275,111 lb.
Steam pressure	7.5 lb.	85 lb.
Feed water entering economizers..	180° F.	180° F.
Feed water entering boilers.......	212° F.	212° F.
Domestic water entering economiz's	40° F.	40° F.
Domestic water after passing through economizers	126° F.	126° F.
Gases on leaving boilers..........	470° F.	470° F.
Gases after passing through water economizer duct	262° F.	262° F.
Gases at stack..................	216° F.	216° F.
Outside temperature	22° F.	22° F.
Water apparently evaporated under actual conditions per pound of coal as fired...................	8.6 lb.	8.3 lb.
Equivalent evaporation from and at 212° per lb. of coal as fired....	8.6 lb.	8.6 lb.
Equivalent evaporation from and at 212° per lb. of dry coal.........	9.2 lb.	9.19 lb.
Equivalent evaporation from and at 212° per lb. of combustible.....	11.7 lb.	11.6 lb.

Saving in 24 hrs. by using feed-water economizers, heating feed water from 180° F. to 212° F.—1,292 lb. coal at $3.30 per ton.................	$2.13
Saving in 24 hrs. by using domestic water economizers, heating domestic water from 40° F. to 126° F.—2,548 lb. coal at $3.30 per ton.............	4.20
Saving in 24 hrs. by using air economizers, heating draft to furnaces from 60° F. to 160° F.—1,616 lb. coal at $3.30 per ton......................	2.67
Saving in 24 hrs. by using returns from buildings instead of water at 40° F.—5,652 lb. coal at $3.30 per ton	9.32
Total, 11,107 lb. coal............................	$18.32
Less loss in tunnels, 1,835 lb. coal at $3.30 per ton.	3.03
Net gain in 24 hrs. in plant of this design.....	$15.29
If low pressure alone had been used for heating it would have taken 1,662 lb. less coal for the 24 hrs., at $3.30 per ton..........................	$2.47

HEATING DATA, BRYN MAWR COLLEGE.

Building.	Construction.	Radiation Direct.	Radiation Indirect.	Lhts.	Power. H.-P.	Distance from P. H. Ft.
Power House	Brick	326	....	105	9	...
Low Buildings	Frame	...	1,083	244	3½	265
Radnor	Stone	300	1,208	282	4	640
Gymnasium	Brick	578	....	172	..	870
Infirmary	Frame	296	....	15	..	975
Merion	Stone	600	1,375	308	7½	1,065
Denbigh	"	450	1,583	365	5	1,385
Taylor	"	300	1,525	394	5	1,250
Dalton	"	1,223	952	548	10	1,575
Pembroke E.	"	350	1,583	...	8	1,635
Pembroke W.	"	...	1,791	705	9½	1,680
Rockefeller	"	743	2,033	591	9¼	1,720
Deanery	Frame	150	417	161	1½	1,550

Total direct radiation, sq. ft. heating surface 5,316 ft.
Total indirect radiation, sq. ft. heating sur..13,550 ft.
Total lights connected 3,818
Total motor load connected............... 72¼ h.-p.

COMPARATIVE PRESSURES IN HEATING MAINS: FROM 10:50 TO 12 A. M., JAN. 19, 1904.

Time. A. M.	Power House Lbs.	Rockefeller Hall. Lbs.
10:50	8.50	5.2
10:55	8.75	5.5
11:00	8.4	5.3
11:05	8.5	5.0
11:10	8.75	5.2
11:15	9.0	5.8
11:20	9.0	5.9
11:25	8.75	5.5
11:30	9.25	6.0
11:35	8.0	5.2
11:40	7.0	4.1
11:45	7.0	4.0
11:50	7.25	4.2
11:55	7.75	4.4
12:00	7.87	4.7
Average	8.20	5.07

Average outside temperature, 10° F.
Distance from power-house, 2,160 ft.
Average loss of pressure for this distance, 3.13 lb.
Average loss of pressure per 1,000 ft., 1.45 lb.
Radiation on line, direct, 1,193 sq. ft.
Radiation on line, indirect, 5,766 sq. ft.

FROM 8:15 A. M. TO 9:15 A. M., JANUARY 20, 1904.

Time. A. M.	Power House. Lbs.	Pembroke East. Lbs.
8:15	8.25	5.0
8:20	8.0	4.7
8:25	7.75	4.7
8:30	8.0	4.6
8:35	8.25	4.8
8:40	8.5	4.8
8:45	9.0	5.3
8:50	9.0	5.3
8:55	9.25	5.2
9:00	9.5	5.5
9:05	9.87	5.5
9:10	9.12	5.5
9:15	8.0	5.1
Average	8.65	5.09

Average outside temperature, 18° F.
Distance from power-house, 1,690 ft.
Average loss of pressure for this distance, 3.56 lb.
Average loss of pressure per 1,000 ft., 2.11 lb.
Radiation on line, direct, 3,797 sq. ft.
Radiation on line, indirect, 6,701 sq. ft.

CONDENSATION, FROM 7 P. M., FEB. 10, TO 7 P. M., FEB. 11, 1904. OUTSIDE TEMPERATURE 22°.

In Tunnels.

Heating surface in steam and return mains in tunnels	21,874 sq. ft.
Amount of condensation	19,448 lb.
Equivalent of coal	1,835 lb.
Percentage of loss of total coal burned....	3.6%
Condensation, per sq. ft. surface per hr., lb.	.0366
Percentage of loss in comparison with condensation of indirect radiation..........	2.5%

In Buildings.

Radiation in use during the 24 hours—
Direct .... 4,200 sq. ft. heating surface
Indirect ....10,440 sq. ft. heating surface

Total evaporation in boilers................	427,850 lb.
Estimated loss in distributing mains in power-house	12,835 lb.
Loss in tunnels..............................	19,448 lb.
Net condensation in buildings...............	395,567 lb.

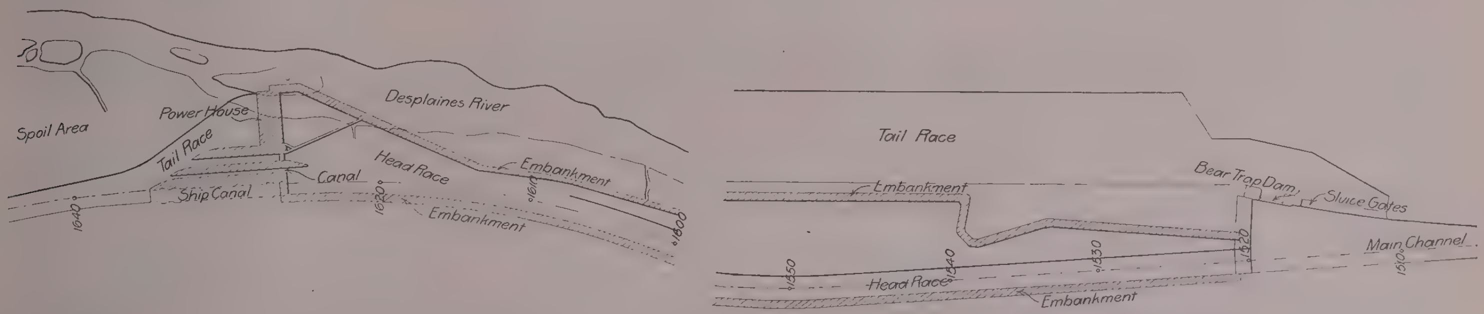
Condensation in buildings per sq. ft. heating surface per hour:—

Direct	.23 lb.
Indirect	1.4 lb.

The Water Power Development of the Chicago Drainage Canal.

The development of the water power produced by building the Chicago Drainage Canal will render available 27,000 h.-p., based on a flow of 600,000 cu. ft. a minute under the obtainable head of 32 ft., and a hydraulic efficiency of 75 per cent. Contracts for the construction of works to develop this power were awarded late in 1903. Construction was not actively commenced, however, until nearly the end of 1904, but that portion of the development to be carried out immediately will be completed during the coming season. The works required to develop the power include the building of a head race 10,700 ft. long, with a uniform channel width of 160 ft. and a minimum depth in this channel of 22 ft., partially in excavation and partially between concrete retaining walls and earth and rock embankments; a 69x386-ft. two-story power house, built of concrete blocks, and a tail race in earth and rock excavation, which is 6,800 ft. long, 160 ft. wide and deep enough to afford a minimum depth of 22 ft. of water. This work involves, according to the contract estimates, 105,000 cu. yd. of earth excavation, 1,273,540 cu. yd. of rock excavation, 366,484 cu. yd. of earth embankment, 997,084 cu. yd. of rock embankment and more than 150,000 cu. yd. of concrete.

The main channel of the Drainage Canal is 28.05 miles long and extends from the west fork of the south branch of the Chicago River, 6 miles from Lake Michigan, to a controlling works at Lockport, Ill. From these works the flow is discharged into the Desplaines River, thence into the Illinois River and finally into the Mississippi River. Branches are to be built to the canal in order that the sewage from large districts lying along the lake to the south and the north from the district served by the main channel may be diverted from the lake into the canal. The plans of the projects of the sanitary district for relieving the lower end of Lake Michigan from sewage pollution and the construction of the portions of these plans that have been carried out have been described at various times in The Engineering Record. The main canal now carries under normal conditions a flow of 300,000 cu. ft. a minute; when the extensions already projected and the contemplated improvements to the Chicago River are carried out this flow will be practically doubled.



Plan of End of Main Drainage Channel, Its Tail Race to the River and the Head Race of the Power Plant.

The bottom of the main channel of the canal at its junction with the Chicago River is 24.448 ft. below Chicago city datum, which is the water level of 1847 in Lake Michigan. The canal is built on a descending grade of 0.025 ft. to the 1,000 ft. in earth and 0.05 ft. to the 1,000 ft. in rock from this junction to the controlling works. The fall in the Desplaines River valley from datum at the controlling works to the level of a large basin, 4⅓ miles below, which was built as a part of the improvements necessary to carry the flow of the canal and the Desplaines River through Joliet, is 42 ft. The present construction is being carried on to develop this head as fully as possible. The arrangement of the controlling works at the end of the main canal is shown in one of the accompanying illustrations. A tail race 600 ft. wide and 6,500 ft. long, which is capable of carrying 1,500,000 cu. ft. of water a minute, was built downstream from these works at the time the main canal was constructed. The upper end of the improvements through Joliet is 11,000 ft. from the lower end of this tail race and between these two pieces of new work the discharge from the canal and the flow from the river are both carried in the original channel of the latter.

The head race for the power development connects with the main canal near the controlling works as shown, and extends downstream practically parallel to the tail race for the latter and to the river. The bottom of the main canal at the controlling works is 30.1 ft. below city datum, while the natural ground surface is only 12.4 ft. below that level. The channel is thus partially in excavation and above the natural surface it is carried by heavy concrete retaining walls backed by earth and rock embankments. The natural surface is 17.5 ft. above the bottom of the channel at the upper end of the head race, and is on a descending grade from there until at the lower end of the head race it is 3 ft. below the grade of the bottom of the latter. The bottom of the head race is level with and is continued on the grade of the bottom of the main canal. The head race has therefore also been built partially in excavation and above the top of the excavation is carried on the left-hand side, going downstream, by a high concrete retaining wall backed by a heavy rock fill, and on the right-hand side by an earth and rock embankment.

The concrete retaining wall and the embankment back of it are a continuation of similar construction on one side of the main canal, and in the first 2,646 ft. from the end of the latter are on tangent. The top of the inner slope of the earth and rock embankment on the right-hand side of the head race is 220 ft. from the inner face of the concrete retaining wall on the opposite side. The head race crosses a highway 1,800 ft. from the end of the canal, and in this distance it is 220 to 380 ft. wide, the earth and rock embankment having been built to conform to the topography of the natural surface. A channel, 160 ft. wide and with one edge 1.5 ft. from the inner face of the high retaining wall on the left-hand side, is excavated, however, the entire length of the head race. The natural ground surface is a loamy soil, 2.5 to 5 ft. deep, which overlies a bed rock formation of Joliet limestone that is more or less seamy and contains some clay pockets. The channel is excavated through this material. The loam over the area between the sides of the head race and outside of the channel is also stripped to the rock.

The width of the head race is reduced to 300 ft. at the highway crossing by curving the earth and rock embankment to the left to provide for a dip in the natural surface. Just beyond this crossing the embankment is turned toward the tail race of the controlling works until the width of the head race is 580 ft. and the embankment joins an old levee along the tail race. This levee is 10 to 15 ft. high and 50 ft. wide, and was formed in making the excavation for that race. The embankment follows the levee for 3,000 ft. About 700 ft. from the turn in the embankment a 1 deg. curve to the right is introduced in the retaining wall side of the head race and is continued for 3,367 ft. The embankment on the right-hand side being inclined slightly to the left in the same distance the width of the head race is reduced to 220 ft. just below a second highway crossing, 5,300 ft. from the upper end of the head race. From the second highway crossing to a point 9,700 ft. from the upper end of the head race the width of the latter varies from 220 to 280 ft. At that point a forebay for the power house 1,000 ft. further downstream, is commenced by inclining the right-hand side of the head race away from the opposite side until the width of the race at the power house is 660 ft.

The tops of both sides of the head race are 5 ft. above Chicago datum. The earth and rock embankment on the right-hand side, between the upper end of the head race and the point below the first highway crossing where it joins the old levee, is 50 ft. wide on top. It is built on the surface of the rock after all vegetable and other matter liable to decay had been entirely removed from the area to be covered by the embankment. This portion of the embankment has an earth core 5 ft. wide on top and with 1½ to 1 slopes on both sides. A rock fill, 22.5 ft. wide on top and with an outer slope of 1 to 1, is placed on each side of the earth core.

From the end of this type of construction to the point where the embankment leaves the old levee, the same arrangement of the earth core with the rock fills on each side is followed, the outer slope of the levee being on the outer slope of the embankment. The balance of the embankment to the beginning of the forebay of the power house is 32.85 ft. wide on top, and has a concrete core wall. This wall is 3 ft. wide on top and is carried up to 5 ft. below datum, or 10 ft. below the top of the embankment. It is battered 1 in. to the foot on both sides and its bottom is built in a trench about 2 ft. deep, depending on the character of the rock surface. The earth fill on the race side of the core wall extends on a slope of 1½ to 1 from a point close to the top of the latter to the surface on which the embankment is built. The earth fill on the other side of the wall is carried up to the top of the embankment, with its face on a slope of 1½ to 1 and is made 9 ft. wide on top. The rock fill on the race side of the embankment is made 7 ft. wide on top and built with its face on a slope of 1 to 1. The remaining 16.85 ft. of the top width of the embankment is made up by a rock fill on the outer side of the earth fill. The material for the earth core is obtained 20 miles above the controlling works from spoil banks made in building the main canal. It is largely blue and yellow clay, and is thoroughly puddled as it is placed in the bank, forming a practically impervious core. The rock that will be used in the revetments on each earth core is obtained from the excavation for the head and tail races.

The concrete core wall used in a portion of the embankments was made of 1 part Utica natural cement, 2 parts broken stone screenings and 5 parts broken stone. The broken stone and the screenings are made from the rock taken out of the excavation. A crusher plant containing a No. 5 and a No. 6½ Austin rock crusher is located toward the upper end of the head race and furnishes materials for the concrete on that end of the work. A plant containing a No. 4 and a No. 6 Austin crusher is placed at the upstream end of the tail race and supplies the work in its vinicity. The crusher run of the broken stone is screened in two sizes, that which will pass a screen with ¼-in. holes and then the pieces which will pass a screen with 1-in. holes. The tailings are run through the crusher a second time. Considerable difficulty was experienced from choking of the smaller meshed screens in these plants when screens with circular holes were used. This was overcome by substituting screens with square meshes similar to those used in handling coal. The concrete was made wet enough to quake slightly under ramming, and was mixed in a large mechanical mixing and elevating plant which will be fully described later.

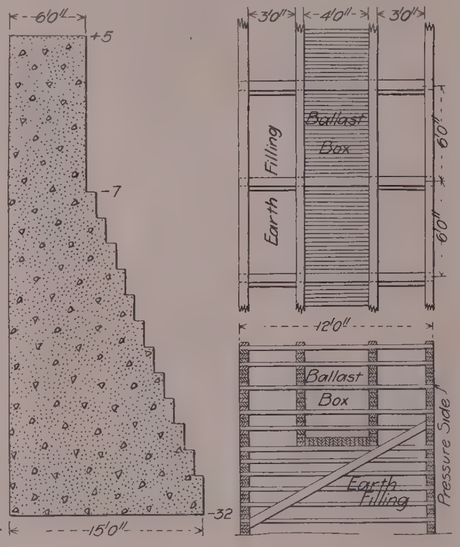
The concrete retaining wall on the left-hand side of the head race is 6 ft. wide on top and has a vertical front face, the base of which is 1.5 ft. back from the edge of the channel excavation. Its back face is also vertical for 12 ft. from the top; below that level it has steps with 9-in. treads and 24-in. risers to within 36 in. of the bottom. The height of the wall varies from 25 to 38 ft., depending on the difference in elevation between the surface of the natural rock bed and the bottom of the 160-ft. channel, the top of the wall being 5 ft. above datum, or 35 ~~ft.~~ above the bottom of the head race. The concrete in the body of the wall is made in the same proportion as that in the core wall for the embankment. The same mixing plants used on the core wall are also used in making it. The wall has a 3-in. coping of 1 to 2½ Portland cement mortar, and the front is faced with the same thickness of mortar for a depth of 14 ft. from the top. This mortar facing and coping is laid at the same time that the concrete in the body of the wall is placed.

The rock fill back of the retaining wall is 44 ft. wide on top and its outer face is on a slope of 1 to 1, so that the minimum width at the top of the retaining wall and embankment is 50 ft. The fill is made with materials excavated from the races and will be brought up level with the top of the wall. The same type of retaining wall and rock fill construction is used in the right hand side of the head race from the point where the latter begins to widen out 1,000 ft. above the power house to form the forebay. The chief reason for using this retaining wall and rock fill construction on the left-hand side was the location of the navigable channel and the dockage on that side. In the greater part of the length of the race on that side the channel of a small stream, and a part of the way the original river channel before the tail race from the controlling works was built, formerly paralleled the site of the race quite closely and provision had to be made to carry the flow in these channels.

The arrangement of the power house at the lower end of the head race is shown in one of the accompanying illustrations. The power house will be a two-story structure, 69x386 ft. in plan, and the walls of its superstructure will be built entirely of concrete blocks. It will be placed with one end abutting against the right-hand side of the forebay. The ultimate power installation for which penstock tubes and wheel pits are being built will consist of eight 4,000-kw. electric generators, direct-connected to vertical turbines. The contract for these four units and an exciter unit has been awarded to the Crocker-Wheeler Company, of Ampere, N. J. The water wheels are being built by the Wellman-Seaver-Morgan Co., of Cleveland, O. These units and wheels will be installed as soon as the power house is ready; the remaining units will be placed when required.

A heavy fender for the coarse screen racks for the power house will be built across the forebay at right angles to the flow to the power house from the latter. The head block for the penstocks for the turbines is being built entirely of concrete and will be outside of the power house structure. The wheel pits are also built of concrete and are in excavations made in the rock formation.

A dam, 50 ft. wide, with a movable crest, will be built on the mid-stream end of the power house to provide for fluctuations in the water level in the head race. The crest of this dam will be capable of being raised 2 ft. above and lowered to 16 ft. below Chicago datum, which is about the normal water level in the canal. The dam is designed to provide for practically all variations that may occur. After the power plant is in operation the controlling works at the end of the canal will be required to handle extreme variations only, except, perhaps, when the power plant is entirely shut down, which will be a very remote possibility. Even with the plant out of operation the dam at the end of the power house will have the capacity to handle the normal flow from the canal. Decision has not been definitely made as to the method of controlling the entrance to the head race from the canal. The present plan is to build a large vertical gate pivoted at the center, in the race near the end of the canal. This gate will swing on the pivots and when closed will seat against abutments built in the sides of the head race.



Sections of Wall and Coffer Dam

Adjoining the movable 50-ft. dam at the lower end of the head race will be a 20x138-ft. lock for the Illinois and Michigan Canal traffic. After the completion of the head and tail races for the power development the traffic in that canal between Chicago and Joliet may be handled in the Drainage Canal. As the Drainage Canal will also intercept the sewage formerly discharged into the Illinois and Michigan Canal, the latter can eventually be abandoned as far as Joliet.

Space is provided beyond the lock for the Illinois and Michigan Canal for an 80x600-ft. lock for a deep water channel. The 160-ft. channel in the head race which carries a minimum depth of 22 ft. of water is reduced to 80 ft. in width at the upper end of the forebay and connects with the site of the large lock. When the head and tail races are finished a minimum depth of 22 ft. of water will be obtained between Lake Michigan and a point about 2 miles above Joliet.

The tail race will be 160 ft. wide and will carry 22 ft. of water for 6,800 ft. from the power house. At the end of this section it connects with the upper end of the widened and deepened channel required to carry the flow of the canal and the Desplaines River through Joliet. The left-hand side of the tail race, going downstream, is in line with the left-hand bank of this channel, the latter having a width of 400 ft. at its upper end. For 4,900 ft. from the lower end of the 160-ft. wide section of the tail race a channel with a minimum depth of water of 10 ft. has been dug through the originally improved channel of the river. The latter narrows down to a width of 300 ft. at the end of the portion in which the 10-ft. channel has been built and connects there with a wide waterway through Joliet.

Rock Excavation.—The methods of handling the rock excavation have been very similar throughout the work. The contractor installed a central air-compressor plant near the second highway crossing below the upper end of the head race and all of the rock drills on the greater part of the work have been operated with power from it. The plant contains two 16x20-in. and 15x25x18-in. Rand air compressors which supply air at a pressure of 100 to 110 lb. An 8-in. main about 600 ft. long extends from the plant to the line of the head race; a 6-in. branch is extended from this main to the point where the tail race joins the wide waterway, a distance of over 1.75 miles. A 4-in. branch about 1.35 miles long, extends to the upper end of the head race.

The specifications for the channel through the rock required the use of machines which would cut the sides of the channel true to line before any of the body of the rock was blasted or removed. This work was all done in the races by four class Y single-gang type channeling machines made by the Sullivan Machinery Co., of Chicago. Each of the machines and the vertical boiler which supplies power to operate it are mounted on a platform which is carried by two pairs of wheels traveling on a track laid along the side of the channel that is to be made. The machines make a cut from 9 to 12 ft. deep at a time. Two of these cuts are necessary in the head race and three in the tail race to secure the proper depth. The material between the side cuts was drilled with standard Rand rock drills operated by compressed air from the pipe line.

The typical method of making the rock excavation on the upper end of the head race was to first set a hoisting engine on an elevated platform on the left-hand side of the channel and about on the line of the embankment back of the retaining wall on that side. An incline was built from this platform down to the site of the channel; a track on this incline was connected at the upper end by a switchback to a track parallel to the channel, and at the lower end to service tracks radiating in all directions over the site of the channel. The excavation was generally carried to grade and worked from two faces, one advancing upstream and one downstream. Six to eight stub service tracks were extended to each face and cars on these tracks were filled by hand. The loaded cars were hauled to the foot of the incline by mules, then up the latter by a hoisting engine to the switchback and dumped in the bank. When the work had progressed sufficiently far a 65-ton Marion steam shovel was installed in the excavation to load the cars, and the latter were handled by small Davenport locomotives. Tracks parallel to the side of the channel were afterward laid on trestle inclines and the excavated material hauled up to the embankment on them.

The rock excavation for the tail race was carried on in a somewhat different manner. The quantity of rock removed from the head race was not enough to build more than 50 per cent.

of the embankment back of the high retaining wall and to make the rock fills on each side of the earth core. The remainder is being obtained from the tail race excavation. Two 65-ton Marion steam shovels are installed in the tail race and loaded the rock loosened by blasting into 3-yd. dump cars on service tracks. An area of considerable extent lying below the power house on the river side of the tail race was first filled to a grade of several feet above the water level in the latter. This area is suitable and will be available for factory sites. The remainder of the excavation is being hauled by Davenport locomotives in trains of 8 to 10 cars to make the fill back of the retaining wall along the head race. The average haul required to transport this material is about 6,000 ft. The service tracks in the excavation connect with a track on an inclined trestle at the upper end of the tail race, built from grade at the bottom of the latter to the natural surface. The tracks on the surface continue for some distance to a second incline leading to a trestle about the center line of and parallel to the embankment back of the retaining wall. This trestle is 30 to 40 ft. high and the embankment downstream from the second highway crossing is nearly all made from it.

The same general methods of channeling and drilling were employed in making the excavation for the nine wheel pits at the power house. These pits are in a row and are each 115 ft. long, 7.5 ft. wide at the upstream end and 32 ft. wide at the downstream end. They are excavated in the rock and lined with concrete, the maximum depth of excavation being 28 ft. A channeling machine and rock drills made by the Sullivan Machinery Co. were also used in this work. Owing to the broken nature of the rock the channeler drills were provided with Z-shaped solid steel bits instead of the five-pieced gang drills used in quarry work. A cut transverse to the tail race was first made at the downstream end of the wheel pits. The material loosened in this cut was loaded in dump cars by a steam shovel and then hauled up an incline to a spoil bank by a hoisting engine. The rock excavated from the wheel pits is being crushed and used in making concrete for the substructure of the power house.

A Lidgerwood cableway was set up over the first wheel pit on which excavation was commenced and the rock handled in buckets by the cableway. The buckets were delivered to a track on a trestle serving a stone crushing plant on the upstream side of the power house site. The rock was dumped from the buckets into cars on the track and delivered by the latter to the hopper of a No. 5 Austin rock crusher. A bucket elevator raised the broken stone as it came from the crusher to a rotary screen which separated the stone in the same two grades that are used in the remainder of the concrete work. The screenings and the 1-in. broken stone were stored in piles near the crusher or used immediately in the con-

Part of Wall Along Head Race

Rock Excavation, Upper Head Race.

Excavation for Wheel Pits.

Coffer-Dam Crib, Lower Tail Race

Steam Shovels, Upper Head Race.

Filling on Both Sides of Core

crete, which was mixed in a Page & Schnable open rotary mixer.

A careful record was kept of the square feet channeled by the machine used on the wheel pit excavations. The best record made at one time was 382 ft. in 12 hours. The total cutting in 40 consecutive shifts during June, 1905, of 10 hr. each was 8,120 ft., or 203 ft. per 10-hr. shift. The machine frequently worked 24 hr. a day and seven days a week, but was run continuously through the entire summer and fall without repairs. In comparison with these records it may be interesting to note the performance of 15 Sullivan channelers used in the construction of the main channel of the Drainage Canal as indicating the improvement that has been made in the manufacture of these machines in the last 12 years. During May, 1895, on that work the 15 machines referred to averaged 116.2 ft. each per shift, as compared with the record of 203 ft. per machine per shift on the present work. The construction conditions on both pieces of work were practically the same and in all cases delays for any reason are taken into account.

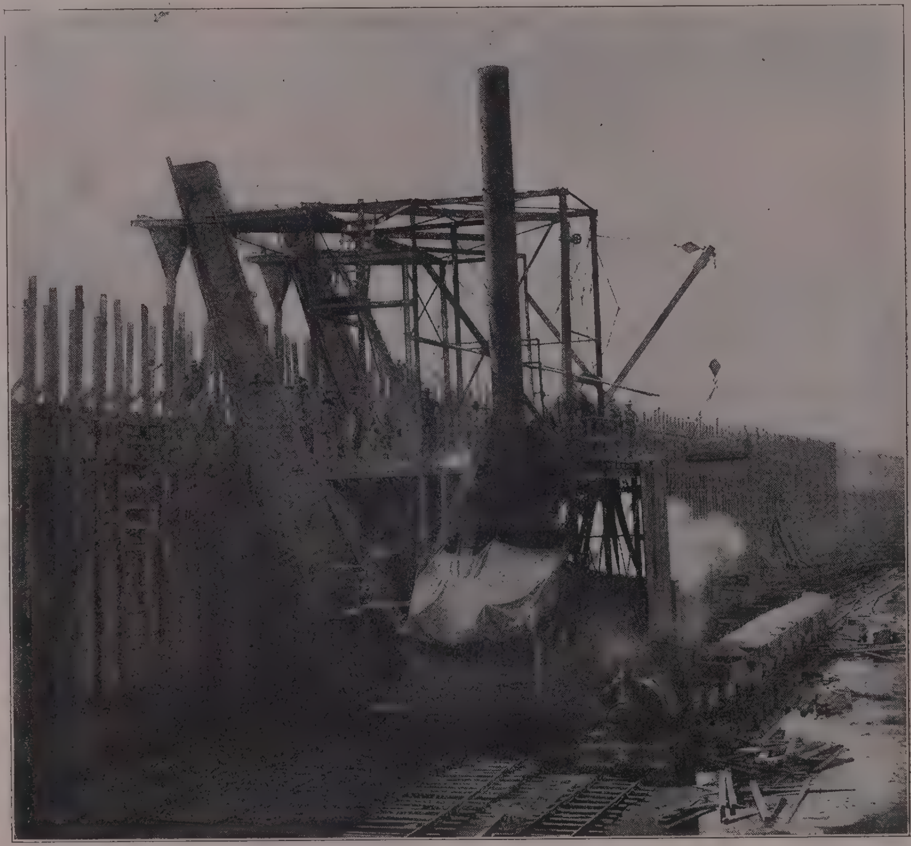
The earth used in the core for the right-hand embankment is brought the 20 miles from the spoil bank on the main canal in trains of 20 to 25 7-yd. standard-gauge dump cars and dumped from a trestle into place. The embankment is thoroughly puddled as it is made with streams from a water pipe line laid the length of the work. In the portion containing the core wall the trestle bents are built with one post and the other end of the cap is placed on a cushion of earth on top of the core wall. The rock for the revetments that are to be placed on each side of the earth fill will be obtained from some excavation yet to be made in the head and tail races.

Construction of Concrete Walls.—The core wall for the right-hand embankment of the head race was built before practically any of the earth filling on each side of it had been made. It is built monolithically, the concrete in it being laid continuously by day and night shifts. The high retaining wall on the opposite side is built with expansion joints. The wall is built in alternate sections, generally 100 ft. long, and the ends of the sections keyed together. A considerable portion of the fill back of this wall was made before construction had been started on the latter. Part of the embankment was made with material from the head race channel by the typical excavation methods employed on that work, and was kept well back of the line of the rear face of the wall. As the latter is completed the embankment is brought to grade between the part built first and the wall from trestles with material hauled from the tail race.

Forms.—The forms for the retaining wall are 2x12-in. plank, dressed on one side and nailed to 4x4, 4x6, or 6x8-in. uprights, depending on the height of the wall. The front and back face forms are all well tied together with heavy wire. The form for the mortar facing is made up of 2x12-in. planks in convenient lengths, nailed to 2x3-in. uprights which bear against the form for the outer wall face. The mortar facing is poured between the outer wall form and the inner sectional form as the concrete is laid. As the height of the wall is carried up the sectional forms for the facing are raised and the mortar and concrete below the bottom of them tamped together before either has an opportunity to set. Owing to the size of the wall the forms have to be torn down and new ones erected as the work progresses.

Concrete Mixing and Elevating Plants.—Two large portable concrete mixing plants built by the contractor have been used in mixing and placing all of the concrete. Each of these plants is mounted on two standard-gauge flat cars running on parallel tracks on about 12-ft. centers. The tracks are laid just inside of the site of the wall, the center line of the one nearest the latter being about 10 ft. from it. The cars are rigidly fastened together by a heavy timber floor and thoroughly braced so that they practically form one wide car moving on 4 sets of trucks on 4 rails. The plant has three working floors. A 100-h.-p. Erie City boiler and an 85-h.-p. Erie engine are mounted on the first floor of the outside car which is at the same level as the regular car floor. The boiler is over the trucks at one end and the engine transversely over the trucks at the other end of the car. The engine is belted to a line shaft on the same car, which drives through a friction clutch a propelling gear on one of the axles of the car. The whole plant is moved along the rails by this gear as a steam shovel is moved.

The concrete materials are delivered to the mixer in the loose bodies of 1-yd. cars on a service track along the outer side. The second floor of the mixing plant is 18 ft. 3 in. from the rails and is built over the inside car only. The third floor extends over both cars and is 21 ft. 9 in. above the first floor. A small stiff-leg derrick and a hoisting engine are placed on the third floor and the car bodies are hoisted from the service track to this floor. There are three 15-yd. sheet-steel hoppers, with their tops flush with the third floor into which the materials are dumped from the car bodies. These hoppers are placed in a row over the inside car. The end hoppers are both for broken stone and the middle one is divided into two parts, one for cement and one for screenings. The double hopper feeds into a mixer on the first floor over the inside car. The cement and screenings are dry-mixed in this machine. Two concrete mixers are placed on the second floor, also over the inside car. Two bucket elevators take the dry-mixed cement and screenings from the mixer on the first floor to a hopper over each of the concrete mixers, one elevator serving each of the latter. These hoppers each have a measuring box and the broken stone hoppers on the third floor also discharge into measuring boxes over the concrete mixers.



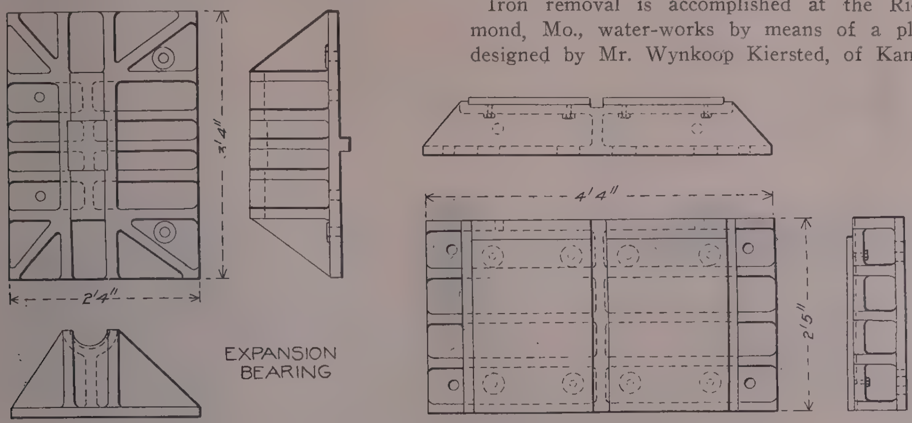
Concrete Mixing and Elevating Plant.

The concrete mixers are of the pug-mill type and are very similar in design, except that they are much heavier, to the mixers generally used in mixing asphalt. Each of the mixers discharges into the boot of one of two slightly inclined bucket elevators on the side of the mixing plant next to the wall. These elevators are each 45 ft. high and discharge at the top into a hopper having a 10-in. opening in the bottom. These hoppers are about over the center line of the top of the wall and well above the level of the latter when the mixing plant is on tracks laid at the grade of the bottom of the head race channel. The opening in the bottom of each one connects with a vertical 10-in. pipe spout. The spouts are in 4-ft. lengths. Each length hooks on the one above and is detachable so that the length of the spouts may be varied with the height of the wall and the concrete delivered to the point where work is in progress.

The mixers and elevators are driven by a line shaft extending the length of the plant on the inside car. Each separate drive is connected with this drive by a friction clutch so that any portion of the plant may be thrown out of service without interfering with the operation of the remainder. The belt drive, the line shaft and the friction clutches are all enclosed to keep out the dust flying from the dry-mixer and other parts of the plant. The engine and boiler are separated by a partition from the rest of the plant for the same reason.

These two plants mixed and placed in the walls 100,000 cu. yd. of concrete during the last season, their average run being 300 yd. each to the 10-hr. shift. Sixteen men are required on each plant, one being an engineer for the engine on the first floor, one a hoisting engineer and the remainder laborers. The wall built of the concrete mixed in the plants has been satisfactory in every way, and although some few changes had to be made before the plants could be operated satisfactorily, the mixers and elevators can now be run practically without interruption.

Cofferdam Work on the Tail Race.—The excavation of the channel with a minimum depth of 10 ft. through the original work done in the river channel by the Sanitary District toward the lower end of the tail race of the power plant was carried on back of a cofferdam which had a total length of about 5,200 ft. The cofferdam extended 160 ft. into the stream at the upper end of the old improvement from the left-hand bank of the latter, thence parallel to the site of the new channel to its lower end and back to the left-hand bank again. It was built with a timber crib filled in the center with rock and the remainder filled with earth, as shown in one of the illustrations. The crib timbers were floated to position and the crib built continuously and sunk in place. Service tracks were run out on the completed work from the shore and the earth and rock were hauled out in cars on these tracks. The bed of the stream was badly broken up by the work that had been done previously and much difficulty was experienced in making the cofferdam tight enough so the pumps could keep the water down. By driving sheet piling on the outside and making a fill against this piling the cofferdam was finally made fairly tight.



Roller Bearing for Girder Spans, Chicago, Burlington & Quincy R. R.

The water inside the cofferdam was removed by two 18-in. centrifugal pumps. After it had been practically all drawn down, an 8 and two 12-in. pumps were required to keep the excavation dry enough so the work could continue. About 5 ft. of excavation was required at the upper end of this 10-ft. channel, the cut increasing in depth to 7 ft. at the lower end. A layer of 2 or 3 ft. of earth covering the rock was first removed and then the rock was drilled and blasted, Jeffrey and Ingersoll-Sergeant standard steam drills being used. The loosened material was loaded on dump cars by two 65-ton Bucyrus steam shovels and wasted in an area between the channel and the old Illinois and Michigan Canal.

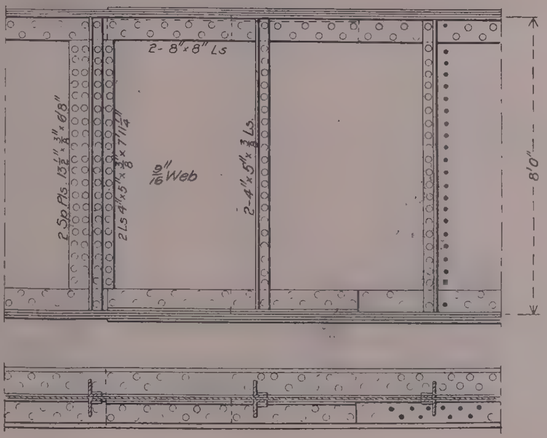
Floods in the Desplaines River broke through the cofferdam twice during the progress of the work and completely flooded the plant at work in the excavation to a depth of several feet. The river flow occasionally reaches as much as 700,000 cu. ft. a minute, all of which and the present flow of the canal, about 300,000 cu. ft. a minute are carried in the 400-ft. channel. When 160 ft. of the width of this channel was cut off by the cofferdam the current was very much increased, but the damage to the cofferdam was due to two exceptional floods.

At least 70 per cent. of the work on the head and tail races is completed. The sub-structure of the power house is nearly finished and the concrete blocks for a part of the superstructure have been made. The power plant will be ready for operation by the fall of 1906. Bids have just been asked for on the screen rack fender at the power house and for the movable dam.

The power development of the Drainage Canal is being carried on by the Sanitary District of Chicago, Mr. Isham Randolph, chief engineer. Mr. Geo. M. Wissner is assistant chief engineer of that district. Mr. W. M. McCartney, assistant engineer, is immediately in charge of the field work on the power development. Mr. L. K. Sherman is resident engineer in charge of the power house construction. The construction of the head race and the tail race down to the work done in the cofferdam on the latter is being carried on by Mr. Joseph J. Duffy, of Chicago. The cofferdam and the excavation behind it were carried on by the Lorimer & Gallagher Co., of Chicago. The excavation for the wheel pits at the power house was made and the construction of the latter is being carried on by the Hayes Bros. Co., of Janesville, Wis.

Removal of Iron from Water.

Iron removal is accomplished at the Richmond, Mo., water-works by means of a plant designed by Mr. Wynkoop Kiersted, of Kansas City. Water is raised by low-pressure pumps from wells to the top of a frame carrying four horizontal sieves, one over the other. It passes through these sieves in a thin spray, becoming fully aerated in this way, and is collected in a circular basin 17 ft. in diameter, from which it passes to an annular reservoir encircling the first. This has a width of 16½ ft. and is surrounded in turn by another annular basin of the same width. Part of this is partitioned off and filled with sand and gravel so as to serve as a sand filter, while the remainder is used as a clear-water basin. The entire structure is built of reinforced concrete, Iola Portland cement being used.



Girder Splice.

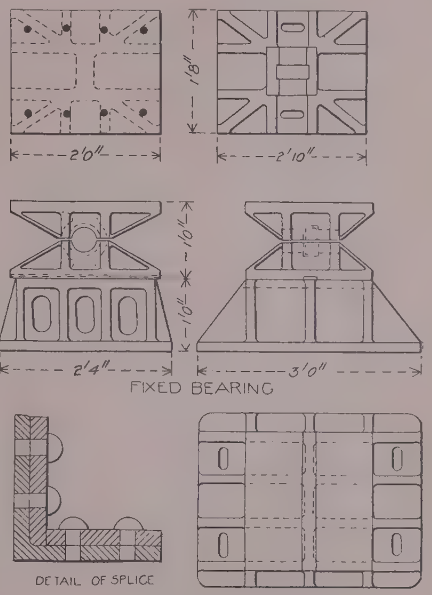
A Gothic Roof of reinforced concrete has been built for a church in Belgium under the direction of Messrs. Aronstein and Luder of Brussels. It has a central span of 23 ft and side spans of 11½ ft. The concrete is covered with mortar and plaster moldings.

Plate Girder Spans on the Chicago, Burlington & Quincy R. R.

Present standards of design for through plate girder spans are illustrated by the accompanying details of an 86-ft. single track span which was erected in 1903 on the main line divisions for the Cripple Creek and for two Rock Creek bridges and at three crossings on other branches of the system. The girders are 8 ft. deep back to back of angles, 86 ft. long over all and 15 ft. 8 in. apart on centers. The depth of floor from top of masonry to base of rail is 5 ft. 4¾ in., allowing 9/16 in. for thickness of rust joint under bolster.

The girders, 84 ft. long on centers of bearings are each proportioned for a static load of 8.4 tons per panel and for total live and dead load moments from of 1,407.8 tons, 1,612.55 tons, 2,439 tons and 2,726 tons for the first, second, third and fourth floor beams. These produce a maximum flange stress of 286.6 tons; the allowed unit stress is 4.72 tons and the actual unit stress is 4.75 tons.

The web plate is made in five sections, spliced with four vertical rows of rivets through pairs of 13½x3⅜-in. cover plates and is stiffened by pairs of 4x5-in. and 4x6-in. vertical angles from 42 to 36 in. apart except over the end bearings, where there are four pairs in a length of 3 ft. Each flange consists of two 8x8x⅞-in. angles 62 ft. 2 in. long and two angles 23 ft. 10 in. long with their joints staggered and each spliced with two ⅞-in. plates 6 ft. 8 in. long as shown in the detail, one full length 30x11/16-in., one 20x11/16-in. plate 60 ft. 11 in. long and one 20x11/16-in. plate 44 ft. 11 in. long. The upper corners of the girders are square and all vertical angles are crimped. The floorbeams 3 ft. deep have their webs made in three pieces, the end sections extending as gusset plate stiffeners to the top flanges of the girders, without stiffening angles on their inclined edges. They are field-riveted to the regular web-stiffener angles of the main girders, and to other angles shipped loose and field-riveted symmetrically with them.



Fixed Bearing.

The lower flanges of the floorbeams just clear those of the girders and have transverse plates riveted to them which are bored for the 1⅞-in. pins engaging the clevises of the 1-in. square lateral diagonal rods. The connection pin plates are filtered out from the floorbeam flanges so as to be flush with the girder-flange-cover plates across which they are field-riveted. The intermediate floorbeams are made with a 9/16-in. web, and in each flange a pair of 8x8x½-in. angles and two 14-in. cover plates. The first cover plate on the lower flange is 7/16-in. thick and reaches to the lateral connection plates, the first one on the top flange is 7/16-in. thick and 11 ft. 10 in. long, reaching beyond the gusset plates so that it is split about 10 in. at each end to clear them, both outer cover plates are ⅜ in. thick and 9 ft. 4 in. long. The end floorbeams are similar but have 6x4-in. flange angles and are somewhat lighter.

The stringers have 28x9/16-in. webs and pairs of 6x4x½-in. flange angles with single full length 10½x½-in. cover plates. The top flange angles are cut 6 in. short at each end and the vertical legs of the bottom flange angles are notched at each end to clear the 6x6-in. vertical end connection angles which have their outstanding flanges milled and are connected to the floorbeams with eleven rivets each. The end floorbeams have solid-web brackets 2 ft. wide riveted to them on the shore side in the planes of the stringers to carry the ties over the bridge seats.

Cast iron shoes are secured to the bottom flanges of the main girders, 24 ft. apart on centers by eight 1⅛-in. tap bolts in each. They have continuous semicircular bearings for 4-in. pins with a projecting 2x¼-in. guide rib in the middle. The pins engage pedestals which are substantially duplicates of the shoes except that they have 2¼x½-in. center longitudinal guide ribs projecting from the base plates to engage slots in the tops of the extended cast iron webbed bolsters 12 in. high to which they are secured by two 1¼-in. bolts in slotted holes. The anchor bolt holes through the bolsters are slotted to allow for adjustment in setting. Bearings at both ends of the span are alike so as to permit temperature movements at both ends of the span.

A 105-ft. deck span dated Feb., 1902, is one of the longest plate girder spans on this road, and illustrates the construction then adopted but which has since been changed in some particulars in accordance with the development of the present specifications and latest standards. The girders are 10 ft. deep back to back of angles and 8 ft. apart on centers. The web is ⅝-in. thick throughout and is made in lengths of 10½ to 12 ft. The maximum spacing of stiffeners is only 6 ft. and there are only two pairs of them over each end bearing. The maximum flange section consists of two 2x2x⅞-in. angles, spliced 39 ft. from the ends of the girder, and three 19x11/16-in. and one 19x¾-in. cover plate. The flange angles are spliced with 8x8x15/16-in. cover angles 8 ft. long and the shoes are bolted to planed 19x1x24-in. sole plates with their edges milled to bear against the ends of the first cover plate and countersunk riveted to the bottom flanges of the girders. Otherwise except for the omission of the floorbeam connections the girders correspond to those described for the 86-ft. span.

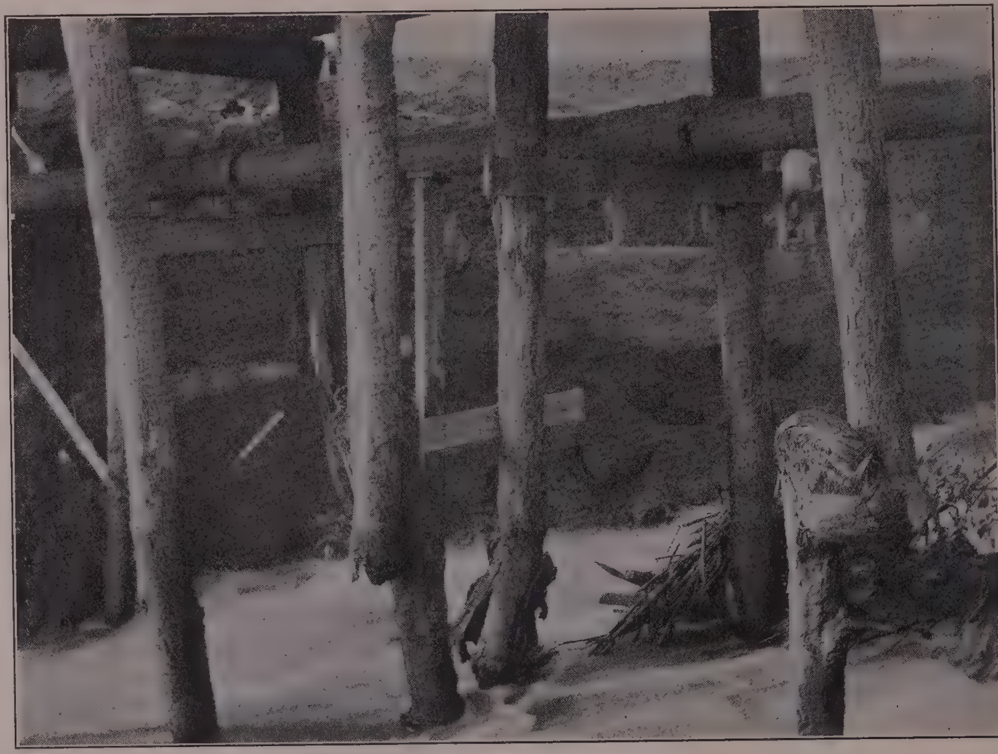
The span is divided into twelve panels by vertical transverse cross frames made with single top and bottom horizontal angles and X-brace angles riveted to the vertical web-stiffener angles. Each panel, between cross frames, is braced in the plane of the lower flanges by a single diagonal lateral angle varying from 6x4 in. at the ends to 3x3 in. in the center of the span. There are no lateral diagonals in the plane of the top flanges. The shoes, pedestals and bolsters are similar to those for the 86 ft. span, but differ materially in detail. The upper surfaces of the shoes are planed and have short flanges engaging the edges of the sole plates on the girders. Their 5-in. pins engage pedestals which are unsymmetrical about the center line of the bearings. The longitudinal guide rib in the base of the pedestal is only ½ in. high at the fixed and where it engages the bolster casting directly.

At the sliding end this rib is 1½ in. high and engages the planed edges of the phosphor-bronze bearing plates 1 in. thick which are tap-bolted to the top of the bolster and with the pedestal base are coated with graphite and tallow. Each bolster is anchored to the masonry with four 1¼-in. rag bolts 11 in. long, which pass through round holes in the base of the expansion end bolster and through slotted holes in at the fixed bolsters. The bolsters are set on ⅝-in. rust joints, and the base of rail is 13 ft. 7¾ in. above the top of masonry.

The girders were each proportioned for a dead load of 0.52 ton per lin. ft., the maximum flange stress is 324.93 tons, allowed unit stress 4.64 tons, required net flange sections 70 sq. in.; actual net flange section 70.77 sq. in. Four spans were built in 1902 across the Nishnabotna River and three spans were built in 1903 across the Cuivre River. All designs were made and construction supervised by the engineering department of the railroad. Mr. W. L. Breckenridge, chief engineer and Mr. C. H. Cartlidge, bridge engineer.

Overdriven Piles.

The inadvisability of always driving wooden piles practically to refusal is exceedingly well illustrated in the accompanying reproduction of a photograph of a few piles that were driven in fairly hard soil until they penetrated only small amounts under blows from a 2,000-lb. hammer. The piles shown are among those that were put down to carry a highway bridge temporarily during the construction of the extension of the Indiana Harbor R. R. near Danville, Ill. The channel of a small stream, which carries a considerable volume of water during certain seasons of the year, had to be changed before the railroad could be built as desired. The new channel crosses a highway at a point where the latter was already carried over an old ditch on a steel bridge with a span of above 50 ft.



Examples of Overdriven Piles.

Five transverse bents of piles with 5 piles to the bent were driven to carry the bridge until the new channel could be excavated and more permanent supports provided for the bridge. The piles were good, sound, straight sticks, obtained locally, some of them being beech and others oak. They were 20 to 25 ft. long and about 8 in. diameter at the small end. They were driven on the average to a penetration of 18 ft. and to practical refusal, a 2,000-lb. hammer on an ordinary derrick pile-driver being used in sinking them. A top layer of loamy soil, 5 or 6 ft. deep, was first penetrated; below this soil is a stratum of glacial drift, with very few stones of any size; and under the drift is a hard clay, not shale, into which the piles penetrated a short distance.

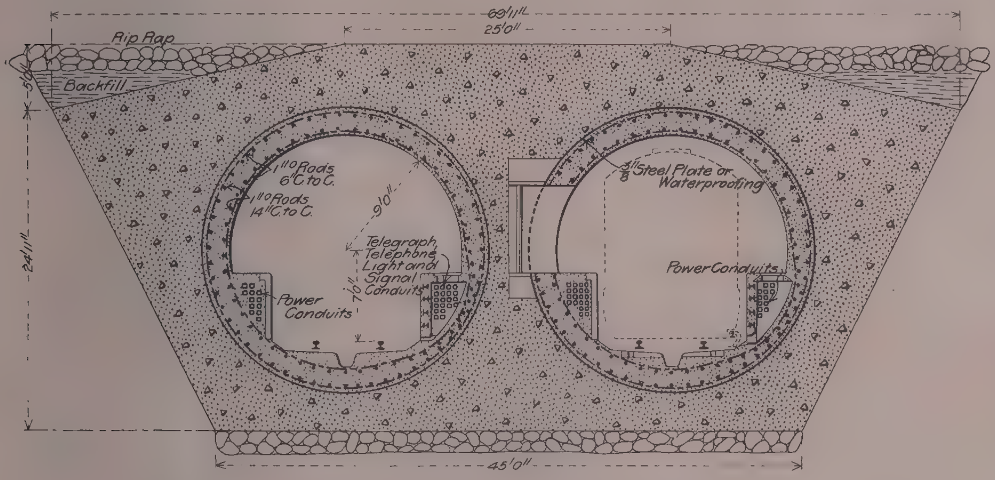
The piles were all driven several days before any excavation was made. None of them showed any evidence in the driving of the damage that was being done to them, going down in the usual manner. When the channel was excavated the results shown in the accompanying illustration were uncovered. Some of the piles had sheared completely in two pieces, others had buckled, while the more pliable ones had twisted badly. At the same time all of the damaged piles came up firm at the end of the driving, even though some of them were ruptured quite near the ground surface. Several of the piles had to be replaced, as they could carry no load.

The experience is considered by Mr. R. B. Seymour, chief engineer of the Indiana Harbor R. R., to be a good illustration of the desirability of stopping pile driving somewhat before the point of refusal. This is to be advised especially where the points of the piles are liable, just before fetching up, to penetrate hard clay or other material that offers much resistance to penetration. Under such conditions the point of the pile may appear to be penetrating, while in reality a rupture is occurring in the body of the timber which permits the head of the pile to sink under the blows of the hammer.

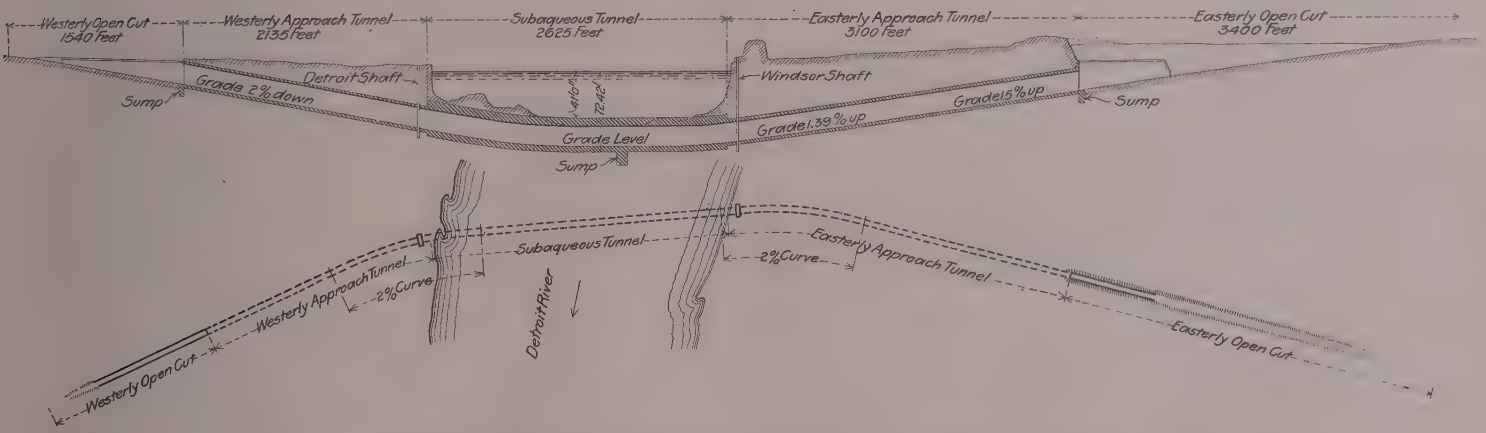
A Riveted Steel Force Main 30 in. in diameter, which was laid across salt marshes about five years ago to bring an additional water supply to Atlantic City, N. J., has developed a considerable number of leaks due to rusting through the shell, which is protected by burlap and mineral rubber. The conditions are very severe on a pipe in this location, owing to the corrosive action of the salt water and the organic matter of the marsh, and it is accordingly proposed to remove the present protection and replace the same with several inches of Portland cement mortar reinforced with steel wire or mesh.

The Detroit River Tunnel of the New York Central Lines.

Messrs. W. J. Wilgus, Howard A. Carson and A. S. Kinnear, the advisory board of engineers of the Detroit River Tunnel Co., a subsidiary company of the New York Central Lines, have completed the plans and specifications for the twin railway tunnels to be constructed under the Detroit River between Detroit and Windsor. The accompanying profile shows the different portions of the work and indicates, by the closeness with which the crown of the subaqueous part approaches the river bottom, the special feature of the undertaking. This is the construction of a tunnel having its roof practically on a level with the bed of the river, a condition which makes the choice of method for conducting the work a comparatively novel task. The Harlem River crossing of the New York Subway and the Chicago River tunnels of the street railways in Chicago are probably the leading examples of such work in this country, but none of them approaches the Detroit River crossing in magnitude. The crossing will begin on the Detroit shore at about Baker and 15th Sts., where an open cut 1,540 ft. long commences. The line follows the present general location of the Michigan Central tracks to the western portal, which is on the line of Vermont Ave., half way between Porter and Howard Sts. The western approach tunnel is 2,135 ft. long and ends about 50 ft. beyond a shaft which the tunnel company is now sinking. This approach has a uniform grade of 2 per cent., and some curvature, which, in fact is continued past the shaft along the subaqueous section of the tunnel for about 400 ft. The subaqueous section is 2,625 ft. long and has the top of the roof of the level portion 41 ft. below the water surface. On the Canadian shore it ends near a shaft which the tunnel company is sinking. The eastern approach tunnel is 3,100 ft. long, has a grade of 1.39 and 1.5 per cent., and some curvature. Beyond its portal the same grade is continued in open cut for 3,400 ft. to the summit. These figures relate to the west-bound tunnel; those for the east-bound tunnel, which lies on the inside of the curve, are somewhat shorter, the total lengths for the west and east-bound tracks being 12,800 and 12,784.6 ft., respectively. The design is based on electrically-operated trains, taking current from the Sprague-Wilgus underrunning type of third rail.



Cross-Section of Detroit River Tunnel, Design A.



Plan and Profile of Detroit River Tunnel of the New York Central Lines.

While the contractors who are now preparing tenders for the work are allowed to present their own plans for carrying on the construction, the advisory board of engineers has outlined four methods which it considers applicable. Plan *A* is a trench method suggested by Mr. Wilgus, plan *B* is a suggestion by Mr. Carson, plan *C* is a modification of *A*, and plan *D* is the usual shield method. In a general way it is considered that the trench method is preferable as reducing the lift of traffic, saving time in construction, reducing the risks of the work and effecting a large saving in first cost.

Design A.—This may be briefly described as a method of replacing the pervious material of the river bed by a semi-impervious hollow mass of concrete, within which, without using shields or high air pressures, the inner tube or tunnel proper may be constructed so as to secure a water-tight piece of work. It also dispenses with coffer dams. The steps to be taken are (a), dredging the trench; (b) placing a 2-ft. bed of two-men stone on the bottom of the trench; (c), constructing working platforms for the plant, which are moved across the river as the work progresses; (d), depositing about 2 ft. of concrete on the stone; (e), placing saddles on the concrete to receive the forms; (f), building, floating and sinking into place the wood or steel forms; (g), surrounding these forms with concrete; (i), constructing the reinforced concrete lining or tunnel proper.

It is proposed to carry on the dredging operations continuously day and night, as not only the early operation of the tunnel road but also the interests of river navigation call for a speedy completion of the work. The filling on the bottom of the trench is to be made of stones ranging from quarry spawls to pieces as large as can be handled with two men. The concrete may be deposited under water by tremie, drop-bottom buckets or bags, the method adopted in any case being subject to the approval of the engineer. In order to prevent an uplifting effect on the tunnel tubes and to afford a continuous support for their lower surface, the use of bags may be preferable to other methods. Where a tremie is employed it must be built of steel and power appliances must be provided for handling it. As a rule it will first be filled with concrete, which will be allowed to escape slowly at the bottom, under the control of a diver, concrete being placed in the top as fast as it passes out at the bottom. The diver is expected to see that the concrete does not fall through the water, but oozes out so as to suffer a minimum disturbance. In passing under and around the tubes it may prove necessary to have curved adjustable lengths provided at the bottom of the tremie for depositing the concrete in places that cannot be reached with straight tubes.

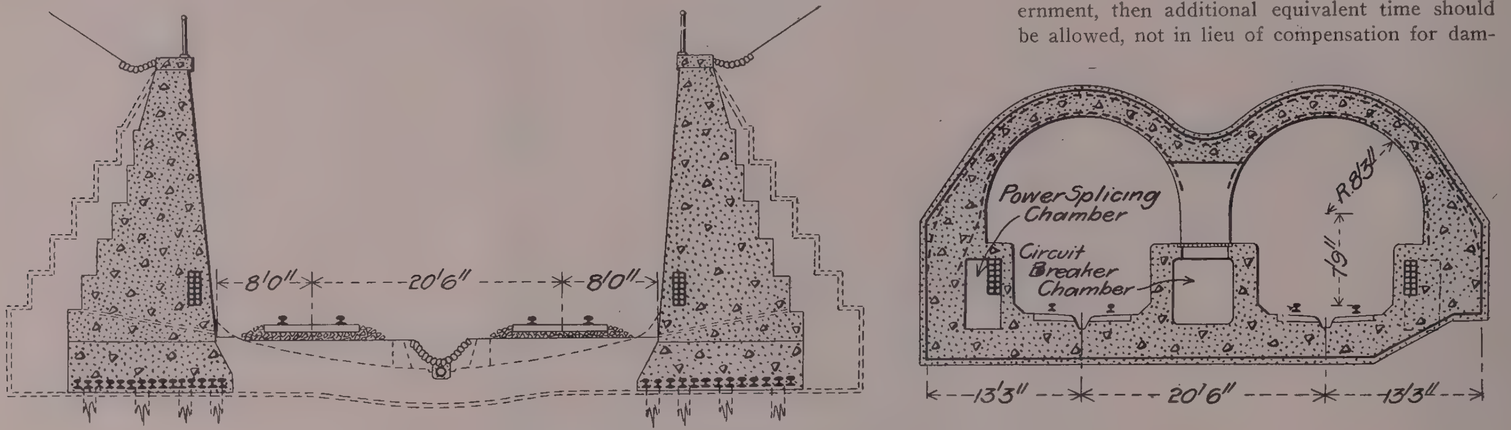
Holes are to be provided in the lower surface of the forms to allow grout to be forced through them into any cavities below the inverts. For this purpose the contractor must use a grouting machine giving a pressure of 60 lb. per square inch.

If steel forms are selected by the contractor, several different methods of preventing their distortion may be employed, such as interior bracing, the use of pipes projecting vertically far enough above the river to cause an outward hydrostatic pressure, or the use of pumps for the same purpose. It is expected that the forms can be made in lengths of 500 to 600 ft. If the contractor elects to join abutting forms under water so as to secure water-tight joints, temporary steel bulkheads must be provided so that in cases of accident the completed portion of the tunnel will not be affected. If the contractor does not join the abutting forms in this way, sufficient separation must be allowed to secure a bulkhead of concrete placed under water in conjunctinn with the placing of the remainder of the exterior concrete, which may be cut away as the work advances. This type of forms serves as waterproofing for the work. If wooden forms are employed, they must be waterproofed with straight-run coal tar pitch and felt. In this method of construction it is expected that compressed air of moderate pressures will be required to repel leakage, so as to permit holding the waterproofing in place while the interior tubes are being constructed.

Design B.—This may be briefly described as a method by which the inner tubes of the tunnel proper are first built in floats or on dry land, floated and sunk into place on a proper foundation, and then joined together so as to secure a strong and water-tight connection. The method is not much unlike that used by Mr. Carson on an outfall sewer at Boston.

The dredging of the trench, placing stone, building a platform and depositing a 2-ft. bed of concrete with saddles for the tubes are the same as in Design *A*. The tubes, after being floated into position, are to be gradually sunk to a proper bearing on the saddles and jointed so as to secure tightness and uniform strength with the main portion of their lengths. Concrete will then be placed around, between and under the lower portions of the tubes, and the upper part of the trench will then be filled in the same way as for the first design.

The tubes are 18½ ft. in diameter inside and 30 in. thick, and reinforced near both inner and outer surfaces. The longitudinal rods are 1 in. in diameter and 14 in. apart for both outer and inner reticulations. The hoops are of 1 in. rods spaced 6 in. apart in the outer reticulation and 12 in. apart in the inner set. The concrete is to be made in the proportion of 1 part of Portland cement, 1½ parts of sand and 3½ parts of gravel or stone broken to 1/16 to ¾ in. The tubes in Design *A* are to be of concrete mixed in the proportion of 1 part of Portland cement, 2 parts of sand and 4 parts of gravel or broken stone of the size just mentioned. In this case the exposed faces will be a 1-in. coat of 1:2 cement mortar. The main base of the concrete will be mixed in the proportion of 1 part of cement, 3 parts of sand and 6 parts of broken stone or gravel.



Cross Sections of Open and Tunnel Approaches of Detroit River Tunnel.

Design C.—This is substantially the same as design *A*, except for details of the steel form and the arrangement of the reinforcement. In this case the outer shell is braced by rings formed of 10-in., 30-lb. I-beams on 40-in. centers. The reinforcement near the inner surface is the same as in design *A*.

Design D.—This method is that of shield tunneling. The necessity of retaining the summits of the tunnel gradients at the elevations selected causes the top of the tunnel to be located so close to the river bed that artificial filling will be required to hold air when a shield is used. The contractor using this method will, therefore, have to place temporary blankets of clay over the line of the tunnel. The two tubes in this design are 30 ft. 3 in. apart on centers and are lined with 2 ft. of concrete, leaving a clear diameter of 9 ft. 1½ in.

The "Indiana" Claim in the Court of Claims.

By George A. King and William B. King, Members of the Bar of the Court of Claims.

The suit of the William Cramp & Sons Ship & Engine Building Co., based upon the contract for building the "Indiana," has recently been decided by the Court of Claims. Interest in the questions involved is not confined to ship building contractors alone, as the principles declared in the decisions are general in their application to government contracts.

The Facts.—The contract for building the "Indiana" was made on Nov. 18, 1890. The vessel was to be completed in three years and the United States was to pay $3,063,000 for the vessel, but the armor plate was to be furnished by the United States to the contractor. The "Indiana" was not completed until Nov. 19, 1895, two years after the date fixed for it. The contractor made claim for an extension of the time as permitted by the contract and the Secretary of the Navy, upon full consideration, declared, as he was authorized to do, that the delays were due entirely to the United States in failing to furnish the armor plate on time. He therefore extended the time for completing the vessel for two years. This suit was brought before the Court of Claims for damages arising through the delay to which they were subjected by the United States and the result of the suit was a judgment in favor of the company for $135,560.

The Defenses.—There were three separate grounds of defense made by the United States. The first was that the extension of time for completing the vessel was the only remedy granted by the contract for delay by the government and that the contractor, by receiving this, was deprived of any right to claim damages on the same account. The second was that the contractor had signed, at the time of receiving the final payment, a full release discharging the United States for any penalties arising out of the claim. The third, going only to a part of the claim, was that before the contract was completed the contractor had released the government from any liability for delay up to that time. These three defenses the Court of Claims considered at great length.

Extension of Time.—The contract provided that, if the completion of the vessel was delayed beyond the time fixed by it, the Secretary of the Navy should decide what was the cause of the delay and whether it was due to the United States or the contractor. The contractor agreed in the contract to accept the opinion of the Secretary on this point, and if he decided that the contracting corporation was at fault, it became liable to heavy damages. The United States contended that when the Secretary extended the contract for a period equal to the delay caused by the government and thereby relieved the contractor from any claim against it for damages, the contractor was thereby granted the full measure of relief contemplated by the contract and could not sue for any damages caused by the government's delay.

The court considered a number of decisions of State courts on this same subject and decided that there were such differences between them and this case that they could not be considered as affecting the rights of this contractor. A conclusion was reached in favor of the right of the contractor to claim damages in spite of the allowance of additional time, the court saying: "The claimant could have completed the vessel within the time agreed upon but for the default of the government; and to hold that the granting of additional time for such default precludes the claimant from the recovery of damages, if otherwise entitled thereto, would, it seems to us, be reading into the contract a provision not in the minds of the parties when the contract was entered into.

"From the language of the ninth clause of the contract it is evident that what was in the minds of the parties was that if, through the fault of the claimant, the vessel was not completed within the contract time, then the penalties by way of deduction from the contract price might be imposed; but if delayed by the fault of the government, then additional equivalent time should be allowed, not in lieu of compensation for damages for such delay, but to enable the claimant to proceed to complete the vessel. As the claimant by the terms of the contract agreed that additional time should be allowed, equivalent to such delay, it thereby waived its right to terminate the contract for that cause; but the question of waiving its right to damages growing out of such delay, was certainly not in the minds of the parties at the time the contract was entered into."

Final Release.—The Court next took up the defense that the contractor had given a full and final discharge to the United States from all claims growing out of the construction of the vessel under the contract by a release signed at the time of final payment. The court said on this subject: "That contention is based on the 6th paragraph of clause 19 of the contract, which reads:

"'When all the conditions, covenants, and provisions of this contract shall have been performed and fulfilled by and on the part of the party of the first part, said party of the first part shall be entitled, within ten days after the filing and acceptance of its claim, to receive the said "special reserve," or the surplus, if any, of the said "reserve fund," or so much of either as it may be entitled to, on the execution of a final release to the United States, in such form as shall be approved by the Secretary of the Navy, of all claims of any kind or description under or by virtue of this contract.'

"The release which was signed by the claimant May 18, 1896, under the provision of the contract is as follows:

"'The William Cramp & Sons Ship & Engine Building Co., represented by me, Charles H. Cramp, president of said corporation, does hereby for itself and its successors and assigns, and its legal representatives, remise, release, and forever discharge the United States of and from all and all manner of debts, dues, sum and sums of money, accounts, reckonings, claims, and demands whatsoever, in law or in equity, for or by reason of, or on account of, the construction of said vessel under the contract aforesaid.'"

After full consideration of the decisions of other courts and a careful examination of the exact terms of the release and of the provisions in the contract requiring it, the court made a discrimination between the claims described in the release "under or by virtue of this contract" and decided that the claim for damages by reason of the delay did not come within its terms and could be covered in spite of the release. The Court said: "Whatever damages the claimant suffered grew out of the breach by the government and not by the claimant in its performance and fulfillment of the 'conditions, covenants, and provisions' of the contract. The claim, therefore, having arisen out of such breach was not the subject of release contemplated by the contract, nor was it embraced in the final release.

"In the present case the claimant was, when it had performed and fulfilled 'all the conditions, covenants, and provisions of the contract,' entitled, 'within ten days after the filing and acceptance of its claim, to receive' final payment, upon the execution of a release to the United States 'of all claims of any kind or description under or by virtue of this contract.'

"As no damage grew out of the performance of the contract by the claimant, no claim was predicated thereon; and as the contract does not provide for the release of claims for damages arising out of a breach by the government, the signing of the final release does not, for the reason above stated, conclude the claimant from a recovery, if otherwise entitled."

Release Pending the Contract.—These conclusions of the court opened the way to the contractor for a recovery on the entire claim, but it was then met by another release signed on May 10, 1894. At this time the work was in arrears under the contract, but the Secretary of the Navy had not decided that the delay was due to the government's fault. There was a large retain provided in the contract which, by reason of the delay, was operating with great severity upon the contractor. A supplemental contract was executed on May 10, 1894, reducing the retain and permitting the advance to the contractor of a considerable sum reserved in the original contract. Then the supplemental contract said: "In consideration of such advance payment the party of the first part hereby releases the party of the second part from all and every claim for loss or damage hitherto sustained by reason of any failure on the part of the party of the second part to comply with its contract or on account of any delay hitherto occasioned by the action of said party of the second part."

The contractor received $234,830 under this supplementary contract and executed the required release. The court said upon this release: "We are not free from doubt but as the contractor, without protest or objection, executed the modified contract and release, they held him to it because on the faith of it the government parted with its money."

They supplemented this conclusion by the following reasoning: "At the time of the modification of the contract and the payment of the money thereunder the question of responsibility for the delay had not beeen determined nor was such delay at the time conceded to have been caused by the government, as no extension of time had then been granted by it, and as the vessel had not been preliminarily accepted nor the work thereon sufficiently advanced to determine whether the materials and workmanship were in conformity with the contract, we think the modified contract and the payment of money thereunder was supported by sufficient consideration, and, further, that the modification of the contract as made was within the authority of the Secretary of the Navy.

"It is a familiar principle of law that one who accepts the terms of a contract in part must accept the contract as a whole. The claimant accepted the money under the contract before it was in fact due, and in consideration thereof executed the release whereby it released the government 'from all and every claim for loss or damage hitherto sustained by reason of any failure' on the part of the government 'to comply with its contract or on account of any delay hitherto occasioned' by it."

As a result of this decision, all the loss and damage which accrued to the government up to May 10, 1894, was disallowed by the Court of Claims and the calculation of loss and damage began from this date and extended until the completion of the vessel. The amount disallowed on this account was $42,263.55. This sum, it seems highly probable, Congress will ultimately pay to the contractor as it was a loss which the company suffered on account of the failure of the government to live up to its contract.

It is not easy for the reader of this opinion to make the discrimination between these two releases which the Court of Claims itself makes, holding the one sufficient and the other insufficient to relieve the government from the claim of the contractor. The court itself admits the difficulty of the discrimination. The final release was declared invalid as regards this claim, because the claim was not within the terms of the release; the former release was upheld on the ground that it was based upon a consideration moving from the United States, that being the payment of money which otherwise would not have been paid at that time. Such consideration was lacking in the case of the final release, as nothing was paid which was not conceded to be then due.

Principles Decided.—The importance of this decision to contractors with the government is very great. It declares, first, that the provision in contracts allowing an extension of time do not operate to prevent a claim for damages for delay for the very same causes on account of which the extension of time is granted. It next declares that any final release executed after a contract is performed, as a condition for receiving payment of what is admittedly due, will be construed with the utmost strictness and not be extended beyond the necessary import of its terms. And, finally, it decides that a release which might otherwise be invalid will be valid if supported by a consideration moving from the United States not then payable unless the release had been excuted.

Some space is devoted in the opinion in determining just what damages would be allowed for delay under such condition. There were four items allowed, the first for the share of the use of the yard, machinery, tools and superintendence properly chargeable to the construction of this vessel during the period of delay; the second for the necessary care and protection of the vessel during the same period; the third for a reasonable wharfage; and the fourth for the insurance which by the contract the contractor was obliged to carry during the same period.

It is understood that there are other ship builders who have claims which will probably now be presented as the result of this favorable decision. The same corporation has claims now pending based on the contract on the "Alabama" and other vessels.

The Storage and Handling of Members for the Island Span, Blackwell's Island Bridge.

The Island span of the Blackwell's Island Bridge will weigh about 24,000,000 lb. including bents over piles, and will have two pin-connected trusses 630 ft. long and 60 ft. apart with an extreme height of 185 ft. at the ends and 118 ft. in the middle, on centers. The trusses will be connected by upper and lower decks providing for a maximum congested live load of 16,000 lbs. per lin. ft. and affording a lower deck 86 ft. wide over all. This span will serve as a connecting or anchorage span for the cantilever arms of the main channel spans of 984 ft. and 1,182 ft. Its erection was, therefore, the first field work to be done on the superstructure and has now made good progress and is in a condition to illustrate many of the principal features of the erection plant and special methods installed and developed for handling this work which excels in magnitude all other work of similar character.

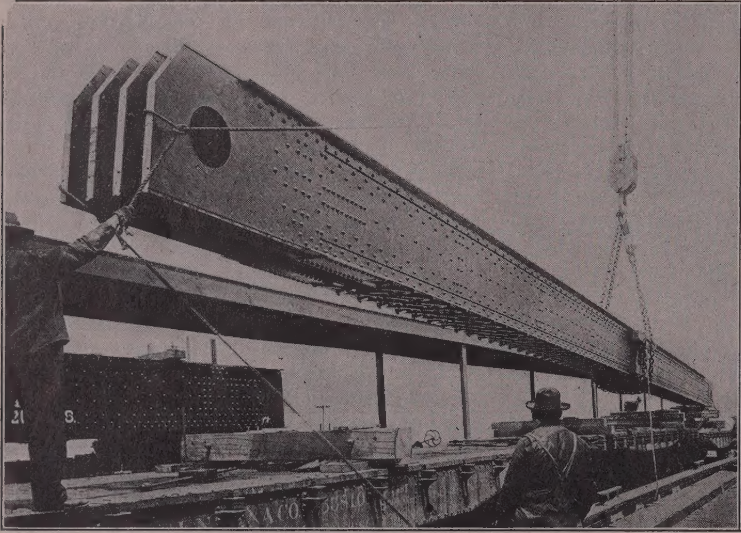
A general elevation and cross section of the bridge, together with a diagram plan and some detail illustrations of the plant installed on Blackwell's Island for the erection of the island span were published in The Engineering Record of March 4, 11 and 18, 1905, and may be referred to in connection with the subsequent descriptions. Operations at this site were commenced in September, 1904. A large pile dock for receiving materials and an iron-sheathed power house, store room, offices, machine shop and tool house were built and a 700x240-ft. area underneath and both sides of the span was enclosed by a high fence. Inside the enclosure the space directly under the span was reserved for the falsework and a portion about 85 ft. wide and over 500 ft. long was devoted to a storage yard commanded by two 65-ton electric gantry cranes of 85 ft. span and 25 ft. clearance above the leveled surface of the ground.

The power house was equipped with a 480-h.-p. battery of boilers, electric generators and motors, pumps and an air compressor to deliver air at 100 lb. pressure through mains extending the full length of the span, for use in riveting, chipping, reaming, etc. At the west end of the span and clear of it, on the north side, there was installed a 65-ton stiff-leg steel derrick of special design similar to that which has been previously used for the erection of the 1,600-ft. span of the Williamsburg Bridge, as described by several articles in these columns. This derrick, which was illustrated in detail in the issue of March 11, 1905, has a 76-ft. boom and a 60-ft. mast. The former has a tapered rectangular cross section made up with four heavy angles latticed and the latter has parallel sides and is made with pairs of heavy reinforced channels latticed. The sills and stiff legs are very heavy riveted pieces corresponding to cross members of railroad bridges.

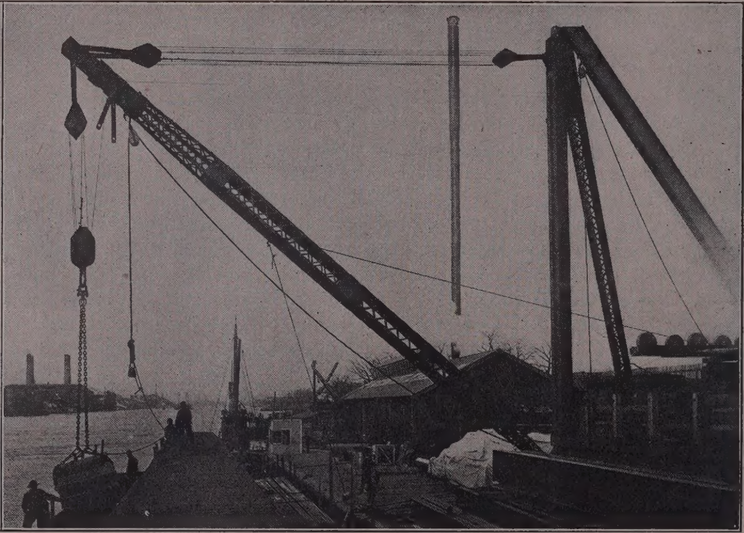
The principal connections are made with pins and special details are provided for anchorage and at the top of the mast where the 8-in. gudgeon pin is seated in a massive cast-steel annealed goose neck. The 12-part topping lift and the 10-part hoisting tackle are made with ⅞-in. plough steel cables and the whole design provides so thoroughly for the great strains that the derrick has been safely used for loads considerably in excess of its nominal capacity. The derrick is located so as to command the center of the dock and reach beyond it and across the car floats. It is thus able to lift the steel from the floats and deposit it on trucks on a pair of standard gauge tracks parallel to the bridge axis which deliver it to the gantry. The steel work of this derrick weighs about 45 tons exclusive of the tackle and the hoisting engine. The latter is a special 3-drum 6-spool machine operated by a

100-h.-p. boiler on engine frame. With it a load of 78 tons has been hoisted at the rate of about 30 ft. per minute, one man only being required to operate the engine.

Steel is shipped from the shop at Steelton, Pa., on platform cars loaded to a maximum of 45 tons, and an average of 35 tons each. These are transferred from the Jersey City terminal to the bridge site, a distance of about 4 miles, on 10-car floats. It usually takes about 8 hours to unload the float, but when the material has been exceptionally heavy it has been unloaded as quickly as 3 hours. For unloading, the hoisting tackle is generally attached to the members with sling chains of different sizes, made of steel up to 1½ in. in diameter. One or more chains are used according to the weight of the piece and are attached to the 36-in. tackle blocks with two sets of shackles, the lower ends of the chains being provided with welded rings so that a loop may easily be formed around the piece. Members weighing as much as 78 tons have thus been hoisted safely from the cars with the derrick boom in nearly flat position, great care being of course exercised. It was not intended to ship pieces of this magnitude complete from the shops, but having been found desirable to do so it was believed that the derricks were competent to handle them and this opinion was justified. Great care was, of course, taken to provide against possible breakages and the derrick and tackles were carefully inspected and watched and operations were conducted slowly and deliberately. Light pieces are handled by a single whip line rigged at the point of the boom and operated by one of the capstain heads of the hoisting engine. Links are also provided for the attachment of lighter tackles which may be operated from a captain head while the engine drums are engaged with the main tackles. The lighter lines and tackles are provided with quick acting clamps and hooks of ordinary construction.



Unloading a Bottom Chord Piece From the Float.

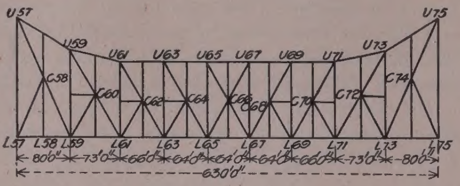


Whay Derrick With 75-Ton Boom.

Up to Jan. 1, 1906, there had been received at Blackwell's Island 24,248,619 lb. of steel including nearly all of that required for the island span and a considerable amount for the adjacent cantilevers. The first steel for the island span falsework was received in December, 1904, and for the superstructure proper in February, 1905. The heaviest piece received is the lower portion of the main diagonal post which has a 39½x43-in. cross section, is 105 ft. long over all, has four heavy webs and weighs about 156,700 lbs.

In general the chord sections were distributed along the full length of the span, parallel to and directly opposite the positions which they will occupy in the finished structure. Other members are arranged as much as possible in the same way, generally being placed with their lengths parallel to the bridge axis. Care is taken to support the pieces on heavy, well leveled blocking on the ground and to interpose transverse blocking between the different tiers of material. The steel has been piled to a height of nearly 20 ft. over a large part of the area commanded by the gantry. This mass of unprecedentedly large members presents a remarkable appearance, and more than anything else tends to convey an impression of the magnitude of the bridge. This is more striking than the appearance of the partially erected structure itself, because the latter is so well proportioned and the members correspond so well among themselves and to the heights of the piers and width of the channel that the scale is not appreciated and it is very difficult to realize the dimensions of members 100 ft. long at a height of more than 100 ft.

Each of the gantries is operated by one man and is equipped with six 50-h.-p. G. E. motors operating three independent hoists at speeds of 8, 15 and 55 ft. per minute. The trolley speed is 100 ft. per minute and the gantry travels 200 ft. per minute. Each gantry weighs about 300,000 lbs., and is designed for shop service after the completion of this erection work. They have been found very satisfactory in the field and are considered to effect a great economy in handling the material.



Island Span

It will be remembered that the bridge is being built under the direction of the department of bridges of New York. Mr. J. W. Stevenson, Commissioner; Mr. C. M. Ingersoll, chief engineer; Mr. O. F. Nichols, consulting engineer; Mr. J. D. Wilkens, engineer in charge; Mr. J. A. Knighton, resident engineer.

The complete contract for both the manufacture and erection of the whole of the superstructure was awarded to the Pennsylvania Steel Company, Mr. J. V. W. Reynders, C.E., vice-president, Mr. Thos. Earle, superintendent of the Bridge and Construction Department, Mr. Fred W. Cohen, C.E., engineer of erection, Mr. L. N. Gross, general foreman of erection. A description of some of the methods of erection will be printed next week.

The Gas Engine Pumping Station at Posen.

A rather unusual pumping station has recently been built in Posen to deliver about 3,800,000 gal. in 24 hours against a head of 230 ft., with a suction lift of 21.4 ft. The pumps discharge into a 20-in. force main 13,100 ft. long, running to an equalizing reservoir, but the distribution pipes are connected directly to the force main so that the water-works system is essentially one of the direct-pumping type. It was accordingly necessary to pay special attention to securing steady and quiet action of the pumps under very variable conditions of load. The pumps were required by the director of the works to consist of two independent units, each of which could be thrown into or out of service without affecting the connection of the other pump to the engine. The equipment finally selected consists of a 250-h.-p. Deutz double-acting suction gas engine and a pair of high-speed double-acting power pumps made by Weise & Monski in Halle.

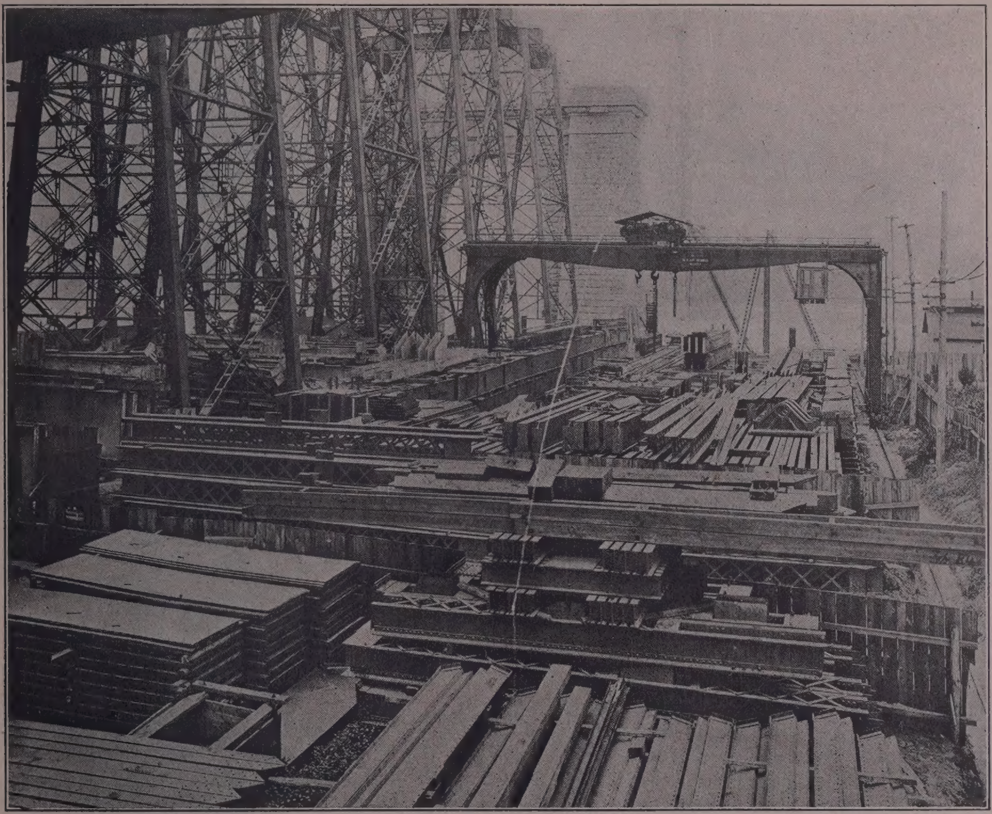
The plant was put in operation a year ago, and last December it was reported by the "Journal für Gasbeleuchtung" to have run successfully from the start. The engine makes 150 r.p.m. The two ends of the main shaft carry flanges to which the shafts of the pumps are rigidly coupled, the throw of the two cranks being 90 deg. apart in order to secure a smooth flow in the force main. The 10-in. pump plungers are made of light Mannesmann pipe and run in bronze liners. Ring valves are used.

As a gas engine can only be started under a light load, large by-pass arrangements were provided for the pumps. These are so constructed that, even when the pumps are running, one side or the other can be thrown into or out of operation. The by-passes have loaded valves and are operated by hydraulic cylinders controlled by small valves mounted near the starting valve of the engine. When the plant is to be started, the attendant by-passes both pumps so that only the friction load must be carried. As soon as the engine has come to speed, the attendant can then, without moving from his place, by the starting valve, throw on either or both pump loads. In this way all the gates and valves that are sometimes employed are rendered unnecessary.

Champfered Fittings are being introduced by a number of manufacturers of pipe fittings, the advantages claimed for them being greater ease of fitting and protection from damage to threads. It is the practice of the Crane Co. to champfer off only the feather edge of the first imperfect thread, there being no object in going further.

Book Notes.

The "Zeitschrift für das Gesamte Turbinenwasen," a publication edited by Mr. W. A. Muller and published by R. Oldenbourg of Munich, has celebrated the completion of its second year by an announcement that hereafter thirty-six instead of twenty-four numbers will be issued monthly. This evident intention to furnish promptly reports of everything of interest in the turbine field is probably an explanation of a considerable part of the success of this journal, although the list of eminent specialists who act as technical contributors and advisers probably has a good deal to do with the popularity of the publication. The papers filed include steam, water and gas turbines, turbine pumps, turbo-generators, turbine ships, centrifugal blowers and rotary steam engines. Its range of contents is from articles of a theoretical character, bristling with mathematical equations, to popular descriptions of turbine installations. In looking over the volume just completed the thoroughness and promptness with which American turbine affairs have been reported is decidedly surprising, and indicates that the articles on work done nearer Munich are probably just as timely.



Material for Island Span in Storage Yard.

Mr. A. Press has written a little book on "Dynamo Design" which will be of interest to engineers who are well acquainted with the actual methods of designing direct-current machines, to which it alone refers. The author takes up in turn the armature diameter and length, the ratio of the pole enclosure to the pole pitch, the armature iron and copper losses, the working densities in the iron and copper, the shape of the slot, the design of the commutator and the determination of the sparking and heating constants. The book is full of novel suggestions and assumptions, which are often stated in such a positive manner that the inexperienced reader may be pardoned for accepting them as expressions of fact rather than as mere speculations. In effect the book seems to have been written by the author for his own amusement and for arousing discussion among other engineers concerning many theories and methods of computation, not all of which have any apparent practical value. The expert designer of direct-current dynamos will find the book full of suggestions which will arouse his interest and often his adverse criticism, but the young man who takes up the subject for the first time should leave the book alone. New York, McGraw Publishing Co., $2.00.

Mr. Philip R. Björling, the author of several books on pumps, has again taken up the subject for the National Trade and Engineering Lectures under the direction of Mr. Ben H. Morgan, and has produced a book entitled "British Progress in Pumps and Pumping Engines." This is a general description of the different classes of pumps built in the United Kingdom, from the little affairs driven by windmills and undershot water-wheels to the largest types of pumping engines. Diaphragm pumps, rotary pumps, centrifugal pumps, triplex pumps and pulsometers as well as the reciprocating types come in for consideration. The text is wholly descriptive and is apparently prepared to indicate to people seeking information concerning machinery of this nature the great variety of equipment that can be procured from British builders. The descriptions are also of engineering value on account of the data they give concerning many typical recent equipments of large and small pumping plants. The volume closes with a classified directory of the British makers of pumps, which is interspersed with sheets of thin paper containing a printed form on which to make inquiries concerning any special kind of machinery. While the book is well-written and well-printed it is somewhat uncertain whether it is not a sort of glorified trade publication for the purpose of building up British trade in pumping apparatus. (Chicago, W. T. Keener & Co.; boards, 8vo, $2.40.)

A good auditing department is necessary to the best operation of any company, large or small, and in the case of a public service corporation it is absolutely essential. Probably no class of such corporations has paid more attention to accounting than the street railway companies; there has been an organization of the accountants of these companies which has accomplished much good in improving the details of the work, while the American Street Railway Association has standardized the general forms of accounts so thoroughly that but little remains to be done in this direction. Accordingly a book by Mr. W. B. Brockway, general auditor of the Nashville Railway & Light Co., entitled "Electric Railway Accounting," will be of interest to a far larger circle of readers than those employees of railway companies actually engaged in such work. It is, in effect, an explanation of the basic principles of accounting, regarded as a means for keeping the executive officers of a company promptly acquainted with the results of every action they may take. These actions must have a financial result, which is the vitally important thing to ascertain as quickly and accurately as possible, and the methods of doing this form the subject of this book. It explains in turn what a report should be and suggests a form for a monthly report. The relation between operating expenses and earnings and some other units of comparison are discussed and some consideration is given to curves as a means of expression of accounts. The general interpretation of statistical information, the standardization of accounts, the balance sheets, accrued and suspended accounts, expert examinations, the accounting department's field, accountants and the accounting office are discussed at length, and there is a very good chapter on taking things for granted. (New York, McGraw Publishing Co., 16mo, cloth, $1.25.)

There has just appeared a "Handbook on Reinforced Concrete," written by Mr. F. D. Warren, which is particularly interesting on account of the author's refusal to be bound by the customary American practice of considering the tensile strength of concrete too uncertain to merit any consideration by the designer. On the strength of tests of two beams, thirteen floors and a roof, constants are deduced which are employed in computing by the theory of elasticity a number of tables intended for the use of architects, engineers and contractors who have to design beams, girders, floor and roof slabs, and roof trusses of reinforced concrete. It is hardly worth while, so long as nearly all engineers absolutely refuse to rely on the tensile strength of a material like concrete, to review the book in detail, for it is wholly at variance with standard practice. The time may come when the elastic theory in all its complexity will be employed to some extent in designing reinforced concrete, but it is a question whether, even then, the empirical formulas will not be retained by most engineers. The leading engineering scientist of the last century, Rankine, was also the leading producer of empirical formulas. The more thoroughly the laws of mechanics are understood, the more inclined engineers become to the use of approximate methods of computation. The reason for this is evident from the book by Mr. Warren; it is based fundamentally on pure theory, then on what he terms "usual assumptions," then on the results of a few somewhat crude tests, and eventually on the assumption that the lower part of all reinforced concrete beams and slabs will be able to carry tensile stresses of 1,000 to 1,500 lb. There are surely enough guesses in this system of computation to make it as empirical as others which frankly neglect theory for assumptions that are always on the side of safety. (New York, D. Van Nostrand Co., cloth, 12mo, $2.50.)

Tables. By Edward Godfrey. Flexible Leather, 16mo, 214 pp., $2.50; published by the author, Monongahela Bank Bldg., Pittsburg.

This book is an interesting example of compilation, prepared apparently in the course of the author's regular work as draftsman, inspector and structural engineer for a period of fifteen years with a leading Pittsburg engineering office. A large part of the contents are taken with little or no change from the hand-books of steel mills, and with only occasional credit. A general acknowledgment is made to the Carnegie handbook in the preface, yet the book begins with two uncredited tables which are copied, even down to the style of the type, from the Cambria handbook. Tables apparently from the Cambria and Pencoyd books and the excellent manual by the Osborn Co. are to be found without very much searching. These are good tables and they would give a great deal of weight to "Godfrey's Tables" if the source from which they were taken were stated. If the preparation of a table consists merely in cutting the data from a book and rearranging the form, the result is in no sense an original piece of work. The tables of the Carnegie, Cambria, Pencoyd and Osborn manuals enjoy an enviable reputation for reliability, and anybody reproducing selections from them will add to the estimation in which his book is held, by frankly acknowledging the source of all such data.

It must not be thought from this general criticism that there is not considerable new material in the book, for it contains data and drawings of real value not published in similar works. This material is arranged in handy shape for use in the drawing office, and includes such tables as areas of angles in terms of the sums of their legs, the moments of inertia of rectangles of a width of 1 in. and depths varying by eighths, diagrams of special roof and portal data, stresses in all the common roof trusses in terms of the total load on the truss, bending moments and weights of girders, properties of built sections, and other data hardly necessary to enumerate. The book differs from the handbooks of the mills in giving less information about the properties of rolled shapes and more about built sections and general engineering data. Some of the special features appear to have considerable usefulness for a structural steel designing room, and the book as a whole deserves examination by draftsmen who have much steel designing to do.

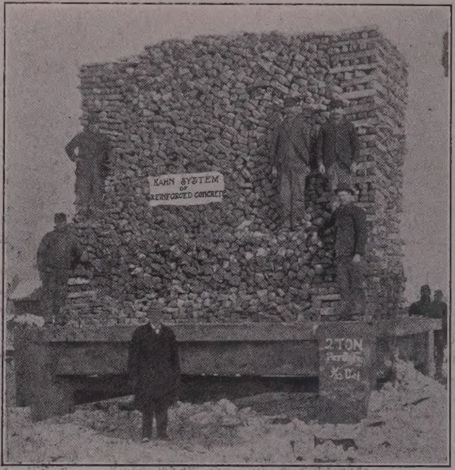
The Judicial Function of an Engineer was brought out in the decision of the Kansas Supreme Court in Edwards v. Hartshorn, 82 Pac. Rep. 520. This was a suit to recover a balance said to be due for 2 miles of grading on the Kansas City, Mexico & Orient R. R. The court says that a provision in a contract between a principal contractor and a sub-contractor for the grading of a railroad that the work should be done under the supervision of the chief engineer of the former, who should make estimates as a basis for the payment of the work done, and that his decision as to all matters of dispute which arose between the parties should be final and conclusive, is valid, and the decision of such an umpire is prima facie conclusive upon all matters submitted to and fairly and honestly decided by him. If there was fraud or mistake so great and palpable as to imply bad faith, or the umpire failed to fairly and honestly perform the function assigned to him, his decision will have no binding force. The fact that the chosen umpire was an employe of the defendant does not of itself weaken the force of his decision, but the law requires of a person so situated the utmost diligence and good faith in the performance of his duties.

Letters to the Editor.

Heavily Loaded Reinforced Concrete.

Sir: I send you under separate cover photograph of a test which has just been completed on a reinforced concrete panel in St. Paul, Minn. The Trussed Concrete Steel Co., through its representative, Mr. Geo. J. Grant, was recently awarded contract for a large hardware warehouse for Nicols, Dean & Gregg, wherein floors are to be designed of sufficient capacity to carry 2,000 lb. per square foot, it being intended that they should carry bar iron set on end. The owners believed it impossible to construct a floor in reinforced concrete with such strength, and at the signing of the contract it was therefore stipulated that a test panel be constructed prior to beginning work on the building.

I am also sending you a blue print of the test showing the construction of the panel and another showing construction of one of the floors in the building. You will note that all of this construction has been reinforced with the Kahn trussed bars. The central beams, supporting an area of 9x14 ft., were loaded with practically all of the pig iron procurable in St. Paul, viz., 256 tons. The original contract called for a test of one ton per square foot over the entire area of the panel, but as the necessary amount of pig iron could not be procured, twice that amount was loaded over the central area. The pig iron was piled 14 ft. in height above the top of the slab, consuming altogether seven carloads of material. Not the slightest indication of shear or other deflection cracks could be discovered under the load, the total deflection being only 3/32 in.



Heavy Loading on Reinforced Concrete.

This test seems especially remarkable, it being in all probability the heaviest test which has ever been made on a reinforced concrete structure, and it shows clearly that reinforced concrete structures may be built with practically any strength desired. The percentage of metal used in these beams amounts to practically 2 per cent. in all cases. It is very certain that all of this metal was brought into play. The building is now being erected by Mr. Grant from plans prepared by the Trussed Concrete Steel Co., of Detroit, Mich., and is approximately 180x100 ft. in area, and is six stories. The individual panels are 15x15 ft.

Yours very truly, M. Goldenberg.

[It is hardly necessary to reproduce the drawings, as they are typical of heavy Kahn construction. The test platform is supported on 2-ft. columns on the corners of a 15-ft. square. The two girders are 20 in. wide and 30 in. deep, reinforced at the bottom with six 1¼x3¾ in. trussed bars. The three floorbeams, dividing the panel into two bays, are 16x26-in., and are reinforced in the bottom by three 1¼x3¾-in. trussed bars and two ¾x2-in. bars of the same type. The floor is 7 in. thick, reinforced in one direction by two ½-in. round rods 7½ ft. apart, and in the other direction by ½x1½x48-in. trussed bars on 28-in. centers, crossing over the floorbeams in the upper part of slab, and by ¾x2-in. trussed bars on 14-in. centers in the lower part of the slab. A cross-section of the slab taken parallel with the main girders shows an arrangement of the reinforcement similar to that in a light Kahn beam.]

Damp-Proofing.

Sir: Modern damp-resisting paints have proved their economy over old-time furring, both as to space saved and general efficiency of results. The proper execution of the work is the vital point, and when this is neglected there is a waste of otherwise good materials and an impairment of the plastering and decoration. This is overlooked too often and sad results ensue. There is a great economy in the use of these paints which warrants at least a fair outlay of labor to secure their proper application.

In a brick wall improperly built, containing deep crevices and pockets having openings to both the weather and the interior, it is useless to expect any material to resist the penetration and consequent pressure of the water; this is often the condition with common work. The damp-proofing is a damp resistant and cannot assume the role of an obstruction against pressure; hence the absolute necessity that all joints, at least those on the exterior and interior sides of a wall, be absolutely full. Only too often does it occur that the cross joints are free from mortar when, on account of rush work, the bricklayer wipes his trowel on the end of the brick and it goes in, whether the mortar drops off or adheres. Opponents of damp-resisting paint have maintained that this makes little difference when an outside wall is furred, but experience shows that moisture and even leaks find ready ingress into walls of such construction and bring dampness within, although it may not be visible, and must in time produce ill effects on account of its absorption by the furring.

Having said this much for the construction of the exterior walls, the application of the damp-resisting paint must be considered. This work should be done by a painter who is a good brush hand. The paint must be well brushed on and all holes and cavities which do not fill up or become positively covered by the paint must be stopped with putty or mortar and retouched. Special care must be given to the surface before the application of the paint; lumps of mortar should be cut off and the surface gone over with wire brushes, particularly in the angles at the floor and ceilings. This must also be done between the beams in beam-filled construction, where steel wall beams or channels do not intercept, and at the reveals of all openings, doors, windows and the like. The purpose is to have the damp-resisting paint form a solid continuous film which, when secured, will positively check all moisture drawn by capillary attraction. Plastering and decorating on a surface painted in this way is perfectly safe, as experience has shown.

Very truly yours, John B. Clement.
New York, Feb. 8.

Experimental Locomotives of three different types have recently been placed in service on the Pennsylvania R. R., including a De Glehn French-built balanced compound, 4-4-2-type American-built balanced compound, a 2-6-2-type simple locomotive and a 2-8-0-type simple locomotive. Each type is being tested under regular operating conditions in duplicate on both the eastern and western lines.